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The United States Steel Corporation.

ITS EFFECT UPON THE BRITISH STEEL INDUSTRY.

THE United States Steel Corporation is now a legal fact, for the necessary registration fees have been paid upon its nominal capital—£600—in the State of New Jersey. This small sum, however, has only been fixed on with the object of obtaining a commercial figure-head for the company, and paying at the same time as little as possible for it to the national exchequer. The real capital of the organisation is 1,100,000,000 dols., or nearly £230,000,000 in English money. This amount is so unprecedentedly large applied to an industrial undertaking as to produce an impression in this country of unwieldiness, and many predict the speedy downfall of the monstrous aggregation Mr. Morgan's exertions have been the means of bringing together.

It is being said upon all sides, in fact, that the American Steel Trust is too enormous to last, and that it must fall to pieces in time by the mere effect of its own weight. We must, however, bear in mind that the Steel Trust, though truly a gigantic undertaking—nothing approaching its dimensions has ever been seen before—is composed of a union of but twelve firms. True, these in turn have their ramifications, but for all considerations that affect management, they may each be regarded as an entity. Each of them is a sound, dividend-paying concern. As a matter of fact, the union embraces a selection of the choicest industrial undertakings in the United States. Each unit is complete within itself, and only requires to be brought into harmony with other similar but not competitive elements for its resources to receive a freer and fuller development. The Trust indeed, in all material respects, is a self-sufficing organisation. It will do all its own work, carry its own goods, and market its own products, paying no one intermediate profits. All these, from the raw ore to the finished product, it will receive itself. The costs of production, it may be inferred, have already been reduced to their lowest practicable limit by the efficient management and perfected plant possessed by the individual firms composing the body of the Trust. All that remains to do is to harmonise the interests of all under one central management, and, by "pooling" the accounts, do away at one stroke with a vast body of accountancy encumbrance. For this purpose a general manager has been appointed—Mr. Charles Schwab—whose salary, though high, being £160,000 a year, is expected to effect an annual saving of £2,000,000. Highly specialised as the different works were before, they will now become more specialised still; for each in future will only undertake that class of product which its natural conditions and plant capacity render it capable of turning out at the lowest possible cost. In every way, the Trust is independent of outside manufacturing industry. It possesses its own mines, its own railways and steam shipping. Even to a certain extent, it provides its own customers, since such parts of its organisation as the American Bridge Company, American Steel Wire, American Hoop, National Tube, and other users of foundry steel comprised within the organisation, will take up a considerable

portion of the main production. But it is not to be expected that these will absorb more than a relatively small proportion of the total steel product of the Trust, estimated as equal to the whole steel product of Great Britain, so that a market must be found outside the Trust for unwrought steel in the vast quantities that will be turned out in excess of its own interior consumption.

This is the consideration that has aroused a great deal of disquieting speculation, not only in this country, but in Germany. Seeing that it is the avowed object of the Trust to reduce in every conceivable way the costs incurred in the production of each ton of steel, and that the same principle will be carried out right through the whole area of its operations, it cannot be left out of sight that one of the main, and perhaps the chief source of manufacturing economy, consists in the obtaining from plant and machinery their full manufacturing value. This can only be done by running them incessantly at their full powers; and when this policy is carried out in its full measure it infers a total disregard of marketing conditions. Low costs can only be secured with large production; what is to be done with the products is quite another matter, and one that concerns this country in a very important degree.

It appears to be the general impression among English steel-makers, so far as we have been able to obtain their views, that the English steel industry has not much to fear from the establishment of the United States Steel Corporation, and some large firms have favoured us with their reasons for this assumption. The first and most prevalent is, that the Trust is in itself essentially unsound, being conceived on a scale of unworkable magnitude, and composed of elements too discordant to work harmoniously together; the second is founded upon a presumption that requires yet to be justified, viz., that the Trust will maintain high prices for its own profit at home, whilst acting upon Mr. Carnegie's "law of surplus" by throwing what it cannot conveniently dispose of in the United States into English markets to be sold at any price, even under cost, in competition with English steel. It is argued that the American public will not suffer a policy of this nature, and be penalised in one of the roots of manufacturing industry by the exactions of a monopoly. It is pointed out that signs to that effect are already forthcoming in the Bill recently introduced into the United States Legislature by Mr. Babcock, providing for the admittance duty free of outside metals.

This is, probably, perfectly true, and a consideration that would have to be taken into account were the inference on which it is founded a substantial one. But neither of those quoted, we think, is based upon anything more sound than individual persuasion. The Trust, with its colossal capital, is thought unsound, because more than one largely capitalised amalgamation has come to grief over here. Because the avowed intention of our own trusts has been to "regulate," or, in other words, to raise market prices, it is assumed that the Steel Trust will pursue a similar policy. Such assumptions are natural enough, but we think they do not apply to this specific case, and for reasons we will briefly set out.

Supposing the Trust established upon a sound economic basis, which many deny, alleging over-capitalisation arising out of exaggerated profit estimates, it is said that should the stability of the Trust be ensured on that economic basis, it would soon become so obnoxious to the country as to be the subject of hostile legislation, and would disappear. It is useful in this connection to recall the formation of a trust more than ten years ago, whose appearance aroused similar predictions, which it has survived to this day. This was the American Tobacco Company, which embodies a gigantic monopoly of the most stringent character conceivable. The formation of this organisation, though attracting little attention here, created a storm of excitement in the United States. It was assumed that it would advance the price of manufactured tobacco, and reap large profits out of its extortions from a defenceless public. The American Tobacco Company, however, continues to

flourish, paying substantial dividends; but it has not increased the purchasing cost of manufactured tobacco a single farthing to the general public, deriving its admittedly large profits through an efficient and economical central administration.

We may look forward, we think, with absolute certainty, to the prospect of the Steel Trust so adjusting its prices that an increase, if any, will be so infinitesimal as to be imperceptible to the American public. Organised and conducted by shrewd business men, it will form no part of their commercial policy to provide an object for the attack of politicians, especially when it has the means of paying the seven per cent. dividend, which is the most its stock-holders must look for, ready to its hand. Nor, do we think, is the prospect of the Trust's selling under cost its superfluous balance of production in this country one to be seriously entertained. So long as the cost of English steel rules the price of the English market, there is no reason why the Americans, with their immensely superior productive facilities, should do so. They are likely to find a sufficient margin in English prices to provide for freightage and other transportation charges, and yet leave them in pocket.

We appear, then, to have to face the problem of a large influx into British ports of American steel, put on the markets at a price which will afford it a preference over steel of English make. Those who profess this prospect an exaggerated one disregard the progressive character of American industry.

The exports of American steel to this country, at present admittedly small, appear to be doubling themselves year by year, so that the 179,000 tons of 1900 may be expected to reach a total of at least 300,000 tons when the current twelve months have expired.

The future of the British steel industry, therefore, is not one we can look forward to with equanimity, especially when we have the example before us of a tin-plate industry already substantially ruined by much the same form of competition as that which menaces us from the formidable organisation just equipped in America. In the face of a threatening and recognised danger some preparations to meet it are ordinarily made. In this case we seem to be doing little—except, perhaps, to minimise in expectation the very hard struggle we shall within a short period be required to engage in—to preserve one of the industries most vital to the interests of the country from irreparable disaster. There are several courses open to us in view of the impending emergency, and two of these are expressed in the following communications, which we print as representative of a number of others received on the subject.

The Steel Company of Scotland are of opinion:

"That it is necessary for iron and steel makers here to do their utmost to reduce cost of production to the lowest possible minimum by the adoption of the latest improvements in methods and machinery."

Colonel Sir Howard Vincent, who represents in Parliament the seat of the British steel industry, expresses himself as follows:—

"Unless British steel producers will go solidly together for a toll upon American and other foreign steel to bring its cost level to that of home production, they may as well shut their yard gates at once. They know this; they sympathise with my efforts, but all in a platonic, half-hearted fashion; and their Parliamentary representatives are equally half-hearted. Foreign nations see our impotence, and take advantage of it."

The time may come before long, when the question of reciprocity in trade will form the subject of State attention; in the opinion of many it has come already. Without expressing at present any opinion on this, it might be pointed out that if the system of a central management spread over a group of allied industries proves so successful in America and Germany, there is no reason why this system should not be equally successful here. In making this reference, however, it must be understood that we draw a very broad distinction between an association formed in this way for the purpose of consolidating and reducing management expenses, and the types of company promotion which of recent years have thrown so much discredit upon manufacturing co-operation of this kind.

Attempts to Increase the Efficiency of Marine Boilers.

READ BEFORE NORTH-EAST COAST ENGINEERS AND SHIPBUILDERS.

THIS paper by Mr. G. M. Brown deals with some improvements introduced, other than forced and induced draught for increasing the efficiency of boilers. He reminds us of the experiments made by a committee, which included Lord Armstrong, to determine the respective values of Welsh and North Country coal. The committee used a wet bottom type of boiler, with an internal uptake, and obtained with it an evaporation of 12·35 lbs. with Welsh coal of 14·3 calorific value, and 12·91 lbs. with Hartley coal of 14·63 calorific value. A feed-heater was used in the base of the chimney.

The author goes on to inform the meeting of Engineers of the North-East Coast that few people have studied the action of the boiler, or endeavoured to increase its efficiency, and, so far as he is aware, no complete measurements of the temperature and pressures of the products of combustion as they pass from the furnace to the chimney. If the author will turn to Sir John Durston's paper, read before the Institute of Naval Architects several years ago, he will find the temperatures he requires all tabulated and set out on a curve for him. He will also find the temperature of the gases in a furnace from minute to minute set out for him by Mr. Houldsworth some 50 or 60 years ago. With the same accuracy he writes of the abandonment of the feed-heater in the uptake, whereas it is being introduced everywhere in this country and America in current times.

Passing from these, the methods to obtain the excellent economy of the system adopted in the Inch line are mentioned. The steam is led through a superheater, and the waste gases, in acting on the superheater, are reduced in temperature from 650 deg. to 450 deg., which is a very low temperature indeed, considering that the water in the boiler is at a temperature of 400 deg. Fifty degrees between the point to which the waste gases could reach ultimately is not at all a bad result. Mr. Kemp did much work of an experimental nature with respect to economisers, and lowered the temperature of the waste gases as they passed up the chimney to 356 deg. This is a very low figure indeed, but we ought to have the temperature of the water in the boiler in order to determine the exact value of the heater. The boilers on which these heaters were fitted must have been very bad; as the temperature of the gases leaving them was as high as 1,040 deg. F. It is hardly correct to state that Mr. Kemp's idea was revived on H.M.S. *Diadem*, and it would be more correct to say that M. Belleville was driven to do something to obtain some economy. And in this connection it may be interesting to observe that these economisers above the Belleville boilers have been condemned by authorities in France and the United States because they are in the fire zone, and because after a short time of working they produce no economy and are rendered useless from pitting.

Retarders and the serve tube are mentioned as other methods of increasing the efficiency of boilers. They at least hasten the transmission of heat from the hot gases to the water, and economise the material and weight of the boilers, and anything which does that causes the cylindrical boiler to approach the water tube boiler in weight power for power. Mr. Blechynden found by experiment that the serve tube was 33 per cent. more efficient than a plain tube. This would be with new tubes, and the relative efficiencies of plain and serve tubes at the end of a voyage from this country to, say, Australia are not given.

On the question of the rapid motion of water and the hot gases over the heating surfaces, it is usual to attribute the original investigation to Osborne Reynolds and his assistants. It is about as true as the claim for Tyndall being the author of the theory of Glaciers. The whole matter was carefully investigated, and the results tabulated by French experimenters long before anyone in England touched with the matter.

The effect of the use of retarders of

different forms are given and compared with the results obtained from the use of plain tubes. In the trial a boiler 10 ft. 6 ins. diameter and 10 ft. 6 ins. long, with two Purvis patent flues, 126 $3\frac{1}{4}$-in. serve tubes 7 ft. 6 in. long, (1) with no retarders, (2) with spirals, and (3) with Scott's patent economisers. The results were, after six hours :—

	No Retarders.	Spirals.	Scott's Economisers
Temp. of feed water...	52·9	58·6	57·5
Steam pressure ...	47	46	47
Temp. of gases at base of chimney..	470·4	422·2	465·9
Lbs. of water evap. from and at 212°	8·89	10 16	10·27

The same total quantity of coal was burned in each case.

The following are the mean results of ten voyages by a steamer running in the cross-channel trade before and after fitting retarders. The ship has two single-ended boilers, each with three furnaces, and the single-ended boiler with two furnaces, all having tubes $3\frac{1}{4}$ in. diameter, and working under natural draught.

	Without Retarders.	With Scott's Patent Economisers.
Consumption of coal per voyage, tons	29·9	27
Revols. per min.	70·5	69·2
Time on passage ...	12 hrs. 20 min.	12 hrs. 12½ min.

"The figures in the first column are the averages for the best ten voyages in the two-and-half years preceding the fitting of the economisers; and in the second column for the ten consecutive voyages after the retarders were fitted, they show a saving of 9·7 per cent. of coal."

The results are given of some of the consumption trials of the Inch line. The *Inch Marlo*, with its superheater fitted to the boiler made the trip from Hartlepool to Dover on ·97 lb. of coal per i.h.p. per hour. We are also told that the *Inch Keith* had the chimney gases reduced to a temperature of 380° F. It is suggested that these waste gases should be further used to heat the feed water.

The author does not appear to quite grasp the nature of a feed-heater nor of the principles on which it depends for its advantages. It would be well if those who take part in the discussion would take up and discuss other improvements which lead to the higher efficiency of the steam boiler. The Belleville economiser, the American feed-heaters, the more rapid movement of the gases through the tubes and their best rate, the better circulation of the water in boilers and the most approved methods for bringing it about—all these are most interesting, come under the subject-matter of the paper, and have not been dealt with.

The Standardisation of Cables.

In our February issue we spoke in terms of approval of the regulations which have been made by the Cablemakers Association for standardising cables, and we referred incidentally to a list of conditions drawn up by the Association to govern all tenders for contracts. These conditions are in themselves quite simple, and certainly are not such as to put obstacles in the way of any body desiring to accept a tender from any firm belonging to the Association. It therefore came as a shock to us to learn that the Brighton Corporation, having invited tenders for the supply of cables, had refused to consider those sent in by members of the Cablemakers Association because of the existence of these regulations, and had given the contract to the Union Cable Company, which has no works in Britain and gets its cables from Germany. As a matter of fact, several of the British firms gave tenders at a lower figure than that given by the Union Cable Company, but all were rejected on the ground that they did not comply with the Corporation's regulations—in other words, that the regulations of the Corporation clashed with the conditions laid down by the Association. What, then, were the objectionable conditions? They were really three in number—viz. (1) The British companies laid down a limit to the quantity of cable which would

be supplied at the prices quoted in the tender; (2) they objected to the regulation that in case of dispute the decision of the Brighton engineer should be final; and (3) they stipulated that the drums on which the cables were wound when supplied should be paid for, but that the full price would be remitted if the drums were returned in three months, and a proportionate allowance would be made if the time which had expired before their return should be more than three months. After a careful consideration of these three points we feel bound to say that there is nothing in them which would justify this astonishing action on the part of the Brighton Corporation. If any of them be serious it is the second, which objects to the Corporation engineer being the final arbiter in case of dispute; but surely it would have been easy to come to an agreement on this point. This stipulation by the Corporation may be common enough in contracts, but it is extremely doubtful whether it is a proper stipulation, for the engineer is a paid servant of one of the contracting parties, and even of a corporation engineer the maxim holds good, *Humanum est errare.* The case for the Corporation is still further weakened by the argument of their engineer that the charge for the drums made the British tenders higher than that of the Union Cable Company, who imposed no conditions as to the return of drums nor as to any other points in the contract. No charge was made for the drums if returned within three months, and only a small charge if returned later; and as these can be of no use to the Corporation when empty and are undoubtedly of use to the cablemakers, the arrangement to secure their return is a most natural one. But there is a still more serious aspect of the whole question. The Union Cable Company has a nominal capital of only £25,000, and the actual capital is £10,000, only £5,000 being actually paid up. The cables themselves are to be procured from Germany. Even by succeeding in retaining for their own official the final decision in case of dispute, can the Corporation imagine that they have the same security in this contract as they would have had by accepting the lower terms of a well-known British firm? We have become accustomed to seeing British firms ousted in competition for contracts by foreign firms submitting *lower* tenders, but it is a new departure to find our firms rejected in favour of a foreign firm which has submitted a *higher* tender. The action of the Brighton Corporation must have arisen either from a misapprehension—this is the most charitable explanation—or from a desire on their part to exercise an absolute power over their contractors. In either case the decision is extremely regrettable, and in the interests of British trade, which even a corporation ought to take some interest in, calls for investigation. If, however, we may judge from the correspondence between the Town Clerk and the Secretary of the Cablemakers' Association which has recently been published, a thorough investigation of all the circumstances is not to be granted. The Town Clerk, on behalf of the Lighting Committee, states that the Association is in error in saying that several tenders were lower than the accepted tender, which was found to be the most advantageous to the Corporation, and declares further that the Corporation are always ready to consider suggestions for alterations in the conditions of specifications, but cannot consent to any alterations in these conditions, when once issued, being made by persons tendering, as this would render comparison of tenders impossible. Both of these arguments are completely upset by the reply of the Cablemakers' Association. It is there shown that even charging for the drums would still have left the lowest British tender nearly £500 lower than the accepted tender; and as to the second point, it is pertinently said that it is impossible to suggest alterations in a specification which they have not seen. But apart from this, the Cablemakers' conditions were communicated to the Brighton engineer in October last, so that the Corporation cannot say no suggestions have been made to them. We have suggested above that the action of the Corporation might have arisen from a misapprehension; but consideration of this correspondence leads rather to the

impression that it has arisen from the tyrannical spirit of a powerful corporation, which is always ready to construe suggestion as being meant for dictation.

Water-Tube Boiler Committee's Report.

THE Interim Report called for by the Press for the purpose, if necessary, of arresting the action of the Admiralty in their policy with regard to the Belleville boiler has appeared, and a drastic document it is. The finding of the Committee is diametrically opposed to the policy of the Admiralty as announced in various official documents. The Report states: "The Committee do not consider that the Belleville boiler has any advantage over other types of water-tube boilers as to lead them to recommend it as the best adapted to the requirements of His Majesty's Navy." And the Committee recommend:—"(*a*) As regards ships which are to be ordered in the future: that Belleville boilers be not fitted in any case. (*b*) As regards ships recently ordered for which the work done on the boilers is not too far advanced: that Belleville boilers be not fitted. (*c*) As regards ships under construction for which the work is so far advanced that any alteration of type of boiler would delay the completion of the ships: that Belleville boilers be retained. (*d*) As regards completed ships: that Belleville boilers be retained as fitted." The Committee then go on to recommend that boilers of the Dürr and Yarrow type be made and tested at the earliest possible date under their supervision. And if it is absolutely necessary to use at once other boilers than the Belleville, they recommend four, three of which are foreign and one English. On this finding of the Committee a good deal might be said; but that which one expert says on this part appears much to the point—"In one part of the Report the Committee deserve to be admired for their innocence. They advise that trials should be made of the Dürr, the Yarrow, as well as of the Niclausse and Babcock & Wilcox types. It may be safely said that there is as much known about the trials and action under every condition and circumstance of each of these types as is known of the Belleville, and anyone who cares can place himself in possession of all that information in a very short space of time. Over a million horse-power of the Dürr, thousands of horse-power of the Yarrow have been fitted, and all the results, advantages, and defects of these types have been known to engineers for years. For the Committee, therefore, to recommend that the country should go to the enormous expense of making further trials and experiments to find out what is already on paper is, to put it bluntly, playing with the question and with the country." But there is one question dealt with in the orthodox fashion—the blame for the mistakes in the designs of the Royal yacht, we are informed by Lord Selborne, Sir William White has gallantly taken, just as Sir George White took the blame of Nicholson's Nek and Lord Roberts took the blame for the hospital scandals of South Africa. It is very noble, no doubt, to do that kind of thing, but it is getting very thin; and FEILDEN'S MAGAZINE, which aims at seeing that Government Departments should be run on business principles, confesses that it cannot join in the general admiration. Playing to the gallery for the condonation of mistakes is somewhat overdone, and it is to be preferred that those costly and useless blunders, which would not be tolerated for a week in a private firm, should now come to an end. FEILDEN'S MAGAZINE, any way, does not consider that a plausible explanation for a blunder constitutes any reason for a condonation of an offence. We must, therefore, state very plainly and very bluntly that we do not agree with the Committee when it brings in the customary finding that "no one is to blame." Someone is to blame for fitting "a fleet of 61 ships" with these Belleville boilers which the Committee condemn. Someone is to blame for fitting them with boilers which reduce their radius of action, lower their speed by several knots, and cause the ships to be quite unreliable to the admiral

under whose flag they steam. Someone is to blame for persisting in fitting these boilers into ships against every advice, against every finding of other Navies, and in face of the protest of the Press. And however disagreeable it may be, it remains the duty of this magazine to point out who the guilty parties are. First, then, in order to trace this matter out, we inquire who penned the Report on water-tube boilers, in which it is claimed that the magnificent fleet of 61 ships had been given a knot higher speed in consequence of being fitted with Belleville boilers? Second, who determined that Belleville boilers should be the standard boiler when the Admiralty agreed to allow Sir William White to fit water-tube boilers into the *Powerful* and *Terrible*? Was the Engineering Department requested to state which water-tube boiler it would prefer? If so, then the Engineering Department of the Admiralty is to blame. And it has sinned against the light, against warnings and against every principle of experimental science. The Engineering Department has not made an ordinary mistake or a common blunder. It is an error in engineering judgment, which is a much more serious affair, and it has hidden its errors by issuing plausible reports which have deluded many people who trusted in its capacity to render the British Navy fit and able to fight. In consequence of this error of judgment, all the new ships remain permanently unmobilised until a change has been effected.

The Kennedy Electric Traction Conduit.

A CONSIDERABLE amount of interest has been aroused by the conduit which Professor A. B. W. Kennedy has recently devised for use on the Metropolitan Electric Tramways which the London County Council are at last taking steps to construct, and a short length of which has been erected as a model at the Council's Camberwell Tramway depôt.

The design differs in some important points from any which are generally known as having successfully withstood the test of time while carrying heavy and continuous traffic. It has in consequence met with a large amount of criticism in the technical press, varying from the expression of the hope that Dr. Kennedy has not been hampered in his design by demands for cheap construction, to an almost indiscriminate condemnation in whole and in every part.

There is, we believe, no difference of opinion among competent engineers that Dr. Kennedy, in addition to his very extensive experience, possesses, to an exceptionally high degree, the power of evolving new designs suitable to meet altered conditions. We should, therefore, be very cautious in condemning departures from standard practice, where the data on which he has based his conclusions are not completely at our disposal.

The design, moreover, has not been got out in a hurry, but, as we are informed, after a tour of inspection of the more important systems of electric street traction in Europe and America.

The Kennedy conduit differs radically from the commonly accepted type in that, as should be evident to any engineer familiar with electric tramway work, it has been designed to meet entirely different conditions. The ordinary type of conduit is the outcome of a good deal of expensively bought experience in the original street railways of New York, where the roads were extremely defective and wanting in solidity. Now, in order to maintain a conduit system in good condition, adequate provision must be made against any distortion arising from settling or other causes, the main danger to be guarded against being such a distortion of the track as would lead to the closing up of the slot through which the plough attached to the car makes contact with the conductors in the conduit. Many failures in early electric tramways in the United States and elsewhere have been due to this cause.

These considerations resulted in the development of very heavy cast iron yokes with wings extending under the track rails, and to which the latter could be bolted, so that the yokes were made

to serve the double purpose of supporting the slot rails and acting as transverse sleepers for making a durable permanent-way. In the earlier conduits the conductors were carried on insulating pillars rising from the bottom of the conduit; but it was soon found easier to keep the conduit clear of mud and other *débris* when the insulators were attached to the upper portion of the yoke, which, owing to its great solidity, was perfectly capable of bearing the additional burden of the conductors.

The same type has been repeated with but slight modifications in most of the comparatively few electric tramways constructed on the conduit principle both in America and in Europe.

In some cases the same type was repeated in order to meet similar conditions to those originally occurring in New York; and in others the type was repeated because it had been a success, instead of designing lighter yokes for use in better constructed roads.

Professor Kennedy, having good solid roads to deal with, has preferred to design a system adapted to them in place of copying one which had been developed to meet different conditions.

In his system the roadway is made to support the track rails, which are laid upon a bed of concrete eight inches in thickness. Six inches only are shown in Professor Kennedy's original plans, but apparently the Highways Committee of the London County Council consider that in this respect they are better judges than the eminent engineer who is advising them.

When the roadway is relied on for the support of the track rails, the yokes need only be strong enough to prevent the slot from being distorted, and any unnecessary addition of metal not only adds to the cost, but by diminishing the homogeneity of the foundations will militate against the smooth running of the cars. The yoke wings supporting the track rails being no longer requisite, the yokes are much smaller and lighter in construction, and besides taking less metal, involve less disturbance of the street originally, and in the case of any replacements that may be necessary, a not unimportant matter in the case of London streets.

The track rails are tied to the yokes with light tiebars, intended apparently to maintain uniformity in the gauge, both during construction and in the carrying out of repairs. The design of the yoke jaws is such as to afford an exceptionally rigid support to the slot rails, which are secured to the yoke by bolts through the flanges, instead of reliance being placed entirely on the support of the webs.

Some of our contemporaries have run amuck against the wooden wedges temporarily used in adjusting the slot rails, and, apparently misled by the booklet drawn up by the Clerk to the Council, have supposed that they were intended to form part of the permanent structure.

The lightness of the yokes has given rise to a large amount of adverse criticism, but entirely on the ground that they are much lighter than the types hitherto in use, for which, as we have pointed out, there are good reasons. The question for criticism in this respect is not merely the fact that the yokes are lighter than the accepted types, but whether or no this lightening process has been carried dangerously far. It would greatly assist engineers to form a properly reasoned opinion on the matter if Professor Kennedy would give details of the data on which he has formed his estimates, and we trust that he may be induced to do this.

Another point which has given rise to adverse criticism is the supporting of the insulators which carry the conductor tees upon pillars rising from the bottom of the conduit instead of attaching them to the upper side of the yoke.

There can hardly be a doubt that this is a drawback, as it will increase the difficulty of keeping the conduit clear of mud and other *débris*, and therefore add somewhat to the expense of maintenance.

To adopt the more usual method would, however, involve the use of heavier yokes than would otherwise be required, and the question at issue is whether the advantage gained in facility of cleaning would be sufficient to warrant the increased outlay involved in increasing the size and weight of the yokes to the requisite extent.

Professor Kennedy has evidently arrived at the conclusion that it would not.

"We are, in the vastness of our possessions, losing our grip on national sentiment. It is our duty to maintain intact, and to defend by sea and land, all that our empire builders have left us. The day that sees the defence of the British Empire sapped, sees the disintegration of the Nation's trade and the hands of civilisation's timepiece put back 200 years."—RT. HON. LORD CHARLES BERESFORD, C.B.

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American "Slimness" . . .

THE United States Vice-Consul General at Frankfort-o.-M., in a recent report to his Government, sends a translation of a short extract from a book on Commercial Treaties, by Dr. Vosberg-Rekow, in which that well-known authority on questions of political economy and cognate subjects speaks with approval of the American system by which every shipment of goods to a United States port must pass through the hands of the American consul, vice-consul, or consular-agent for the district from which the goods are sent, and the amount, value, place of origin, market price ruling in the country of production, the method of production, and similar data are carefully noted. In virtue of this system the United States obtains valuable information, which is utilised to the best advantage at home, and, naturally, is of great assistance to American exporters, who know exactly what is wanted abroad and where it is wanted, and, consequently, have not to work blindly or to pay dearly for the lessons of experience. Still more important is the fact that the Americans obtain all this information practically gratis, since the foreign producer or shipper not only is obliged to supply the above data, but has to pay more or less heavy fees for the consular signature, which alone is taken in proof that these formalities have been fulfilled. This explains the presence of the great number of practically unsalaried American representatives one meets everywhere abroad, and who yet find their position acceptable, since their income from fees is greater than that which many of them would be able to earn in their own country. Dr. Vosberg-Rekow would like to see a similar system established in Germany, and thinks that German industry and commerce would be considerably benefited if the number of German consuls and consular-agents in foreign countries, charged with a minute and careful inquiry into the condition of the export trade to their own country and the working methods of the manufactories and business houses abroad, were greatly increased, and if, like the American consuls, these officials were to be paid by fees collected from the foreign producers. To render this system still more effective, he thinks, only such persons ought to be appointed to these posts as are not themselves merchants, and therefore have no private aims to pursue that might render them unfit to represent the aggregate commercial interests of their country; while, in order to insure the completeness and uniformity of the reports to be sent home by these agents, the latter should, in his opinion, be supplied with regulations and schedules distinctly stating what data are required. Our readers will grant that these views deserve consideration even on the part of our own manufacturers and merchants, and that this feature of the American consular system has certainly practical advantages, though it cannot be called a very dignified *modus operandi*.

With reference, however, to other features of their consular service, our transatlantic relations have not much to boast of either as regards the personnel or the achievements of the latter, for we must not forget that the bulk of the American consuls and consular-agents abroad have no other qualifications or claims entitling them to their positions than some more or less legitimate services rendered, at election time, to the victorious party. Many of them, were it not for the aid of their clerks—usually natives of the country where the consul resides—would be unfit for even the ordinary routine work, though nearly all of them can manage the collection of the fees alone; and as regards the reports drawn up by these officials, the bulk might as well be relegated to the waste-paper basket. Of course, there are praiseworthy exceptions, such as Colonel Mason, the Consul-General at Berlin, for instance, and a dozen or two others, among them a few distinguished American writers. These exceptions, however, only prove the rule, and many instances might be given to show the qualification of some of these gentlemen for the inquiries that they undertake and report upon.

Once more, our Patent Laws . . .

In an editorial which appeared in the May issue of this magazine last year we drew attention to the very able paper read before the Manchester section of the Society of Chemical Industry, by Mr. Ivan Levinstein, on the shortcomings of our patent laws. He, like most of us, deplored the absence of a provision for preliminary investigation, the opposition to which, he said, principally came from the Chartered Institute of Patent Agents, since the adoption of a search system would deprive its members of a lucrative part of their business; and, among other facts, he pointed out that our present patent laws did not confer a shadow of a secure title. For these and other reasons Mr. Levinstein strongly advocated a thorough reform; but, as he had anticipated, his strictures and suggestions created a good deal of uneasiness in the camp of the patent agents, and Mr. C. D. Abel, one of their best-known members, undertook to become the champion for what he and his colleagues appear to consider their vested rights. In his reply, however, to Mr. Levinstein's arguments he resorted, it now appears, to the refuge of all defenders of a weak cause—namely to an unfair and misleading arrangement of data, and Mr. Levinstein, in a paper recently published in the *Journal of the Society of Chemical Industry*, had no difficulty in exposing the stratagem of his opponent, and showing that none of his arguments had been refuted. Mr. C. D. Abel, in order to invalidate Mr. Levinstein's assertion that our patent laws fail to give a secure title and are a constant source of expensive litigation, and that this to a great extent is due to the absence of preliminary search, made the statement that in Germany, for instance, where such search exists, titles are equally or even more insecure, and in support quoted the number of patent litigations registered in that country in 1896. He forgot, however, to mention a fact of which, in his position, he can hardly have been ignorant—namely, that in the year 1896, selected by him, an altogether exceptional number of patents was invalidated and withdrawn, as is evident from the fact that the average of the four preceding years amounts to only 15·5 cases. Equally misleading was Mr. Abel's attempt to show that preliminary investigation, such as exists in Germany, did not establish the validity of a patent or secure the rights for the true inventor. For this purpose he drew attention to the fact that patents were refused in Germany both for the Siemens regenerative furnace and for the Bessemer process. This, at a first glance, seems, of course, to be a strong argument against the uselessness of search, but in reality it has nothing whatever to do with it; for as Mr. Levinstein points out, these patents were applied for not only years before the law of preliminary search came into force, but even before there was any German Patent Office. This, we think, will suffice to show how weak is the position of those who object to reform in our patent laws.

Earnings of the Record Liners of the North German Lloyd.

THERE is an idea abroad in this country that fast liners on the Atlantic do not pay. Shipowners of this country have laid down the doctrine that the average speed mail steamer, with its low consumption of coal, is the safer ship for an investment, and this doctrine has been held as an article of faith for several years now. These shipowners have consequently stated that if Great Britain has a wish for faster mail steamers, the Government ought to pay a subsidy to the company which is willing to build and run them. We have always held that this is a short-sighted policy, and that the companies engaged in the Atlantic traffic must place themselves in a position to compete in speed with their rivals if they wish to hold their own on the Atlantic. The balance-sheet of the North German Lloyd Company completely bears out our opinion. On every other line in which they are engaged the balance-sheet shows a decrease, the exception being the Atlantic fleet, which has earned an enormous increase in its profits. That this would happen was quite evident from the reports of the enormous profits earned on each voyage. During last season the *Ivernia*, one of the average speed and large cargo steamers of the Cunard Company, earned £10,000 on her best trip, while the cost to the company of the trip was £4,000. This left a clear profit of £6,000 for the best voyage, and apparently the Cunard Company intends to sit down contented with these results. It is a safe investment and a respectable profit, and the English habit is to sit down under the circumstances content. Not so the North German Lloyd. They have been determined for long to gain the blue ribbon of the Atlantic, and now they can point with triumph to the result of their policy. The *Deutschland* on her best voyage earned £28,600, while the cost to the company for the trip was £10,000. This left a clear profit of £18,600, as against £6,000 for the best voyage of the *Ivernia*. The report says:—"The increased profit on the transatlantic line results from the increased freight from the new steamers put on the line during the year, and a considerable increase in the number of passengers carried." The increase in the number of passengers carried is from 197,226 to 253,225—an increase of 55,999, which is 28 per cent., while the profits are £1,089,220, an increase of £530,680. This is very instructive, for it is clear that the *Deutschland*, which left only 600 tons for cargo, depended entirely on passengers for its profits. The pursuit of its policy in aiming for the better class of passenger has been fully rewarded with success. Every other item shows a decrease: the Imperial mail lines of £82,250, the European lines of £1,920, and other subsidiary matters; but these decreases are all made good by the tremendous rise in the transatlantic profits earned by the new fast liners. The proposal of the directors to pay a dividend for the year of 8½ per cent., against 7½ per cent. last year, the result of the year's working, is a clear and emphatic vindication of their policy with respect to fast liners, and the shareholders of the Cunard and White Star companies will be perfectly justified if they should insist on the directors of those companies initiating forthwith a more forward policy.

ENGINEERS are invited to communicate to the Editor of FEILDEN'S MAGAZINE the result of their investigations in any field of Industrial Progress. If suitable, an original account of the improvements which they have effected in any branch of Manufacturing Industry, New Processes which they have discovered, or Inventions which they have brought to a state of commercial value, will be published over the signatures of the contributors, and high-class engravings produced free of cost to the writers, which will be employed to illustrate the articles.

The unparalleled publicity which FEILDEN'S MAGAZINE affords to anything new which appears in its pages, will thus be of the greatest value to the contributor, whose investigations will be brought prominently before the engineering and industrial world.

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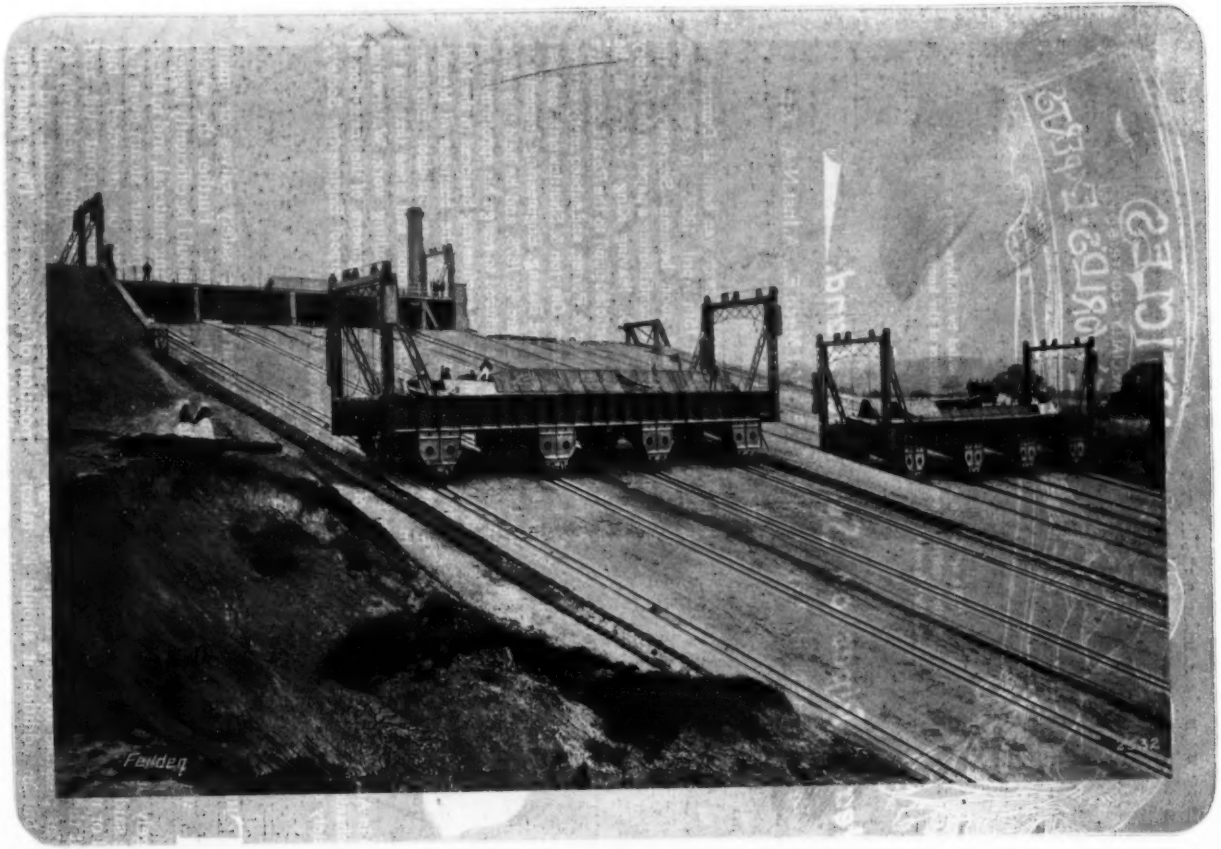
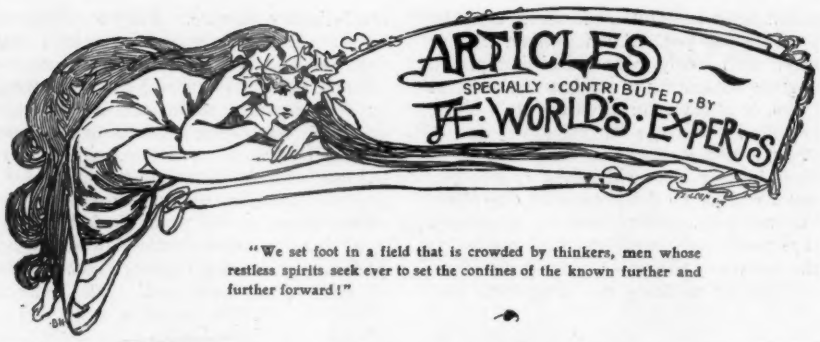


PATENT BARGE LIFT AT FOXTON, LEICESTERSHIRE.

ERECTED FOR THE GRAND JUNCTION CANAL COMPANY BY MESSRS. J. & H. GWYNNE, LD.,
FROM DESIGNS BY MESSRS. G. C. AND B. J. THOMAS.



"We set foot in a field that is crowded by thinkers, men whose restless spirits seek ever to set the confines of the known further and further forward!"

Steam Pipes on Sea and Land.

By STEPHEN H. TERRY, M.Inst.C.E., M.I.Mech.E., A.Inst.N.A., &c.

MR. STEPHEN HARDING TERRY was born at Dummer, in Hampshire, on 15th April, 1853. In 1870 he went to King's College, and soon became Secretary of the Engineering Society there, contributing a paper on the History of the Steam Engine. On leaving King's College at the end of 1871, he went as articled pupil to the Road Locomotive Works of Messrs. Aveling & Porter, and subsequently entered the employment of Messrs. Clayton & Shuttleworth, and was appointed by the late Lord Basing, Engineering Inspector to the Local Government Board, in 1878, and he held this office until 1889, when he was induced to resign his appointment in order to join as partner an engineering business in the Midlands. At a later date he joined the business of Messrs. Bunsted & Chandler, Hednesford, as out-door Engineer. In 1893 Mr. Terry came to London, and since that time he has been chiefly engaged in Consulting work, Waterworks, and in Arbitration work. He is a Member of the Institution of Civil Engineers, of the Institution of Mechanical Engineers, of the Institute of Marine Engineers, of the Liverpool Engineering Society, Society of Arts, and an Associate of the Institution of Naval Architects.

THE question of economy or waste by auxiliary engines (on board ship) working at the ends of long lengths of main steam pipes, is largely one of the proper arrangement of the said pipes.

For not only should great care be taken that the steam as it leaves the boiler is as dry as possible by being taken from high up, but in addition it should be taken from a point as much as possible away from the direction in which steam is flowing towards the safety valves or main steam pipe valves. Further, the whole lengths of pipes should be efficiently lagged with good insulating material, and in these days of very high-pressure steam even the flanges should also be protected; but there is a more important point still, and that is the size of the pipes relatively to their work and their direction and the position of drain cocks. These points are all liable to be very much overlooked.

In the early days of auxiliary machinery

steam pipes were often too small, whereby pressure was lost. A reaction set in, and now, with fairly economical compound engines exhausting to condenser, the steam pipes, or at least the auxiliary main pipes, are often too large for the rapid flow of steam; and if there be long lengths of them horizontal, or with slight up gradient, water will lie in the bottom of the pipes, increasing in quantity until the steam area is reduced sufficiently to cause ripples on the surface of the water lying in the pipes, still further reducing the area, when suddenly the whole volume of water gets dragged along by the steam, and assumes a piston form technically known as slugs, and delivering a hammer-like blow on any obstruction. These slugs, coming suddenly upon high-speed engines (with very little clearance and fitted perhaps with piston valves which do not lift off the face), are certain to do damage.

The author was present some eight years ago on board a large mail ship, as engineer-in-charge, fitted with four 6-ft. 6-in. fans and single-acting engines; these fans weighed about 12 cwt. each, and ran about 350 pipes revolutions a minute. They were driven by tandem compound single-acting engines, and were so arranged as to exhaust either to atmosphere, condenser, or low-pressure steam chest of main engines. They took steam from the main boilers by means of a 6-in. pipe, which led fore and aft about the level of the low-pressure cylinder covers. From this pipe athwartships on the port side led off four 2-in. branch pipes; these also began horizontally, leaving therefore some 2 ins. of main pipe undrained. The branch were about 8 ft. in length when they took an upward bend to a height of perhaps 9 ins., again becoming level just before reaching the stop-valve. (Figs. 1 and 2.)

At this point ½-in. drain pipes were fitted, and these had to be kept constantly open, blowing out, however, very little water, but wasting lots of steam. The water leaped over the openings in consequence of its momentum whilst coming with the steam in small doses. All went well until the trial trip was nearly completed, when water, having accumulated in the 6-in. main (in larger quantity than

FIG. 1.—DRAIN COCKS IN STEAM PIPES.

FIG. 2.—BRANCH PIPE FROM MAIN STEAM PIPE LEAVING 2 INS. UNDRAINED.

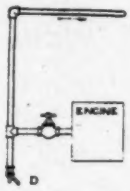


FIG. 9.—ARRANGEMENT FOR DRAINING STEAM PIPE.

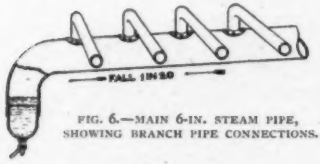
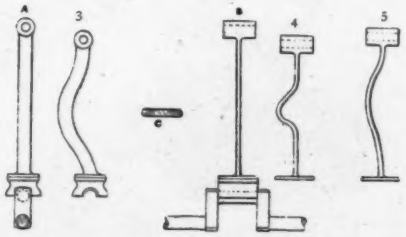


FIG. 6.—MAIN 6-IN. STEAM PIPE, SHOWING BRANCH PIPE CONNECTIONS.

FIGS. 7 AND 8.—DRAIN COCKS FITTED AT BENDS IN STEAM PIPE.



FIGS. 3, 4 AND 5.—DETAILS OF BENT CONNECTING-RODS CAUSED THROUGH WATER ACCUMULATING IN CYLINDERS OF AUXILIARY ENGINES IN MAIL BOAT.

the engine relief valves could pass), came along, and three out of the four engines were instantly brought to rest, not being able to work as hydraulic engines, having piston-valves, lead, and no clearance. These engines had their connecting-rods bent, as shown in our engravings, Figs. 3, 4, 5; but after the connecting-rods were put in the fire and straightened, the engines worked as well as ever. *A* and *B* represent the connecting-rods before the accident, whilst *C* is a section of the rods.

The pipes were afterwards provided with drain-cocks at a lower level, which ought to have been done at first. The fan engines, which were tandem-compound, were afterwards fitted with low-pressure relief-valves, in addition to those fitted in the high-pressure cylinders. These defects were both pointed out to the patentee and designer of the engines (in the shops whilst the engines were building), who, however, like many inventors, was of that temperament which would only learn by breakdowns, the breakdown in this case nearly costing him the loss of the introduction of his machinery into our largest mail fleet, and somewhat imperilled the adoption by that fleet of that beautiful system for the conservation of energy known as Howden's forced draught, by which the heat in the waste gases is made to warm the incoming air. It is right, however, to state that these engines and fans were not of Howden's make, although we believe that now his own type are always fitted wherever the system invented by himself and so successfully worked out and fitted by him, aided by Mr. Robert Bruce, whose perseverance (albeit quite equal to that of his ancestor) has only just, after nearly ten years' successful working in the Mercantile Marine, succeeded in getting the Admiralty to adopt the Howden system!

It often happens on board ship, from the exigencies of space, that pipes have to assume shapes very far from those which would be desirable in order to ensure dry steam. The first point to aim at is to have the steam and any water of priming or condensation flowing in the same direction, not to have the water trying to get back to the boiler against the flow of steam. To do this the summit level of the pipes should be attained immediately on leaving the boilers. From this level the pipes should fall steadily towards the engine stop-valve. Water, when it gets into a steam pipe, tries to flow nearly in straight lines; if, therefore, drain-cocks or automatic relief-valves are fitted, they should be fitted at dead ends or at the point where there is a bend (Figs. 7 and 8). The water has a tendency to leave at a tangent, and if branch pipes have to be fitted they should rise where possible from the top of the main pipe, which must be kept adequately drained (Fig. 6); and if by chance the engine to be supplied is at a lower level than the branch pipe, it can generally be arranged so that the momentum of the water will cause it to shoot past the opening to the steamchest, leaving only dry steam to enter the water passing out at *D*, Fig. 9.

The provision of proper arrangements for expansion on heating and subsequent contraction is also a point which is greatly overlooked. The difficulty can be got over in a number of ways, of which the expansion joint, with gland and stuffing-box, is probably the least scientific and the most costly. It has the obvious disadvantages of being liable to leak if not carefully packed, or of becoming set fast and ceasing to act as an expansion joint; also, if of bad design, it may on slacking the nuts blow right out. In any case, when dealing with high-pressure steam, if the pipe be of more than 2 ins. or 3 ins. in diameter, it must not be lost sight of that it is liable (unless properly designed in the first instance and properly adjusted afterwards) to substitute for expansion and contraction strains those due to a piston, whose area is perhaps 20 ins. or more, and on whose surface 200 lbs. per inch of steam is pressing. Another form is the double diaphragm or bellows type of expansion joint. These are well so far as they go, but if the length of pipe is considerable and the range of temperature also large, it will be necessary to provide several, as their movements are limited.

The scientific and best way is to provide for moderate expansion—say $\frac{1}{4}$ in. to $\frac{3}{8}$ in.—a good, bold, curved bend, but

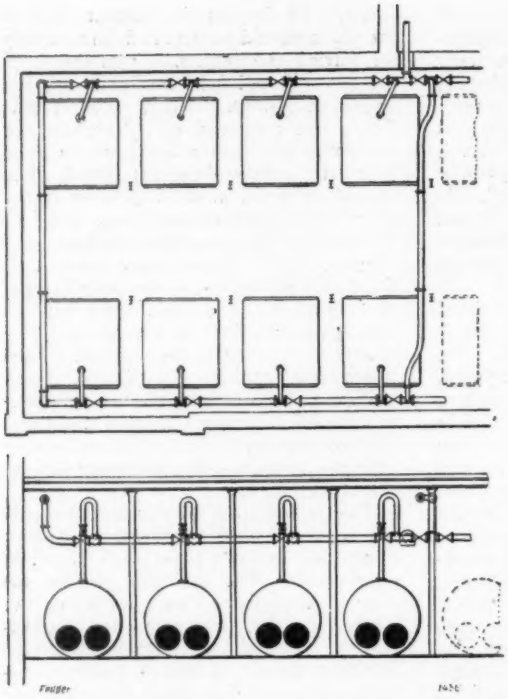


FIG. 10.—RING ARRANGEMENT OF STEAM PIPES ON KENNEDY'S SYSTEM IN BOILER HOUSE.

when anything over this has to be provided for, the pipe should make a complete circle in spiral form, with a radius of not less than 8 to 10 diameters of the pipe. Arranged thus considerable movements can be provided for, and as there is no change of section and all motion is spread, lagging is easy, whilst the flow of steam is not obstructed as in the case of abrupt changes of section.

To endeavour successfully to free steam pipes from water, the general principle aimed at should be analogous to that used both in town drainage and in water storage, and known as a leaping weir.

In the case of town drainage it may happen that provision is made for dealing with a fixed maximum flow of sewage daily (the dry weather flow), but the works may be quite inadequate to deal with the extra volume produced by a thundershower; all that can be done with such extra volume containing quantities of road detritus, etc., is to turn it into the river. The leaping weir accomplishes this automatically, the ordinary flow reaches a portion of the invert where there is a sudden depression for a length of say one diameter of the sewer, the main sewer being continued beyond the depression at a level of some few inches less, the ordinary flow running in the sewer a quarter or even less full, at a velocity of 2 to 3 ft. per second, falls into the depression, which has some large holes in it, and the whole of it falls through these holes to the outfall sewer below whence it enters the works. Should a storm of rain occur, the sewer runs two-thirds full at an increased velocity and leaps the depression, entirely passing out at the storm overflow beyond.

We often find so-called water separators designed on erroneous lines, as for instance, those in which the incoming steam comes at the side of a cylindrical reservoir, the outlet being opposite or upwards with a vertical diaphragm plate between the inlet and outlet. Against this the water strikes, and the designer hopes that it will immediately fall and settle quietly in the lower part of the reservoir. There are two reasons why it does not do this, except partially. They are: first, it strikes the plate with such violence that it breaks into spray, going out again in this form with the issuing steam; secondly, because so far even as such water that remains on the vertical diaphragm is concerned, this water has to run the gauntlet of the steam rushing past the lower edge of the diaphragm, whence as it falls off in drops it is

rapidly blown along and carried out with the issuing steam.

The proper way to make a cylindrical water separator is to bring the supply steam-pipe in at the top of the casing through the cover, to point it vertically downwards and some 18 ins. or 2 ft. from the water level in the separator, to make the lower edge of this pipe with a bevelled sharp edge, so

will really give dry steam. The ordinary separator very frequently should be properly described as a maker of spray.

Such an apparatus may, it is true, prevent to some extent the advent of slugs to the engine, but it cannot give dry steam or prevent wasteful condensation and re evaporation in the engine cylinder, where, if no adequate relief is provided, sooner or

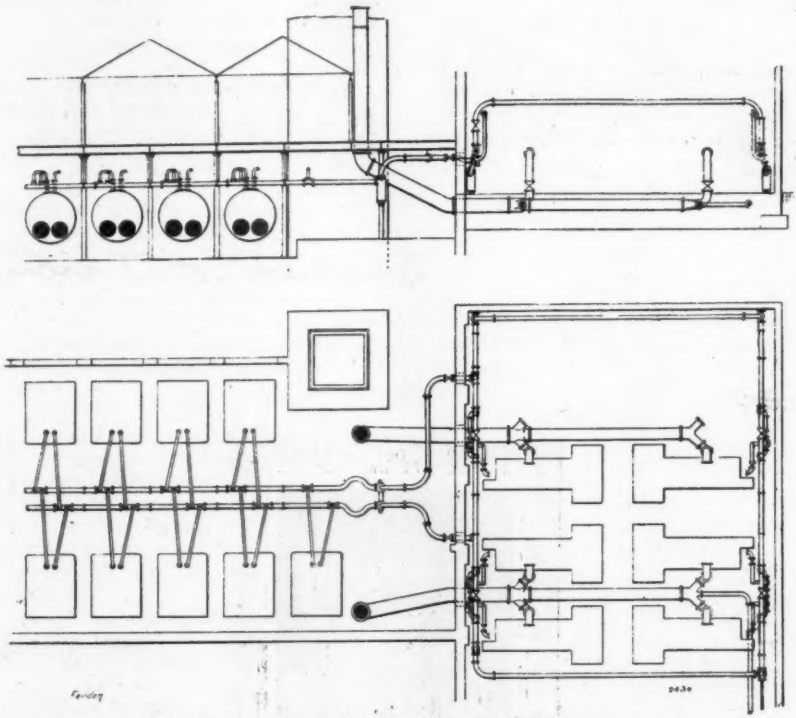


FIG. 11.—ARRANGEMENT OF STEAM PIPES FOR ELECTRIC LIGHT CENTRAL STATION ON PROFESSOR KENNEDY'S SYSTEM.

that no water may hang on in drop form to be afterwards carried along.

The outlet should be through holes or ports in an annular casing just under the cover, leading to one horizontal or vertically placed outlet straight on to the engine stop-valve.

A separator so constructed of sufficient dimensions, properly lagged and drained,

later it will cause a breakdown. And apart from this very grave risk, sufficiently indicated by our illustrations, the presence of water entirely prevents that silence in running which is at once soothing to the passenger in a steamship and the engineers. One most important step towards this result is undoubtedly the elimination of water from steam. It has been shown that this

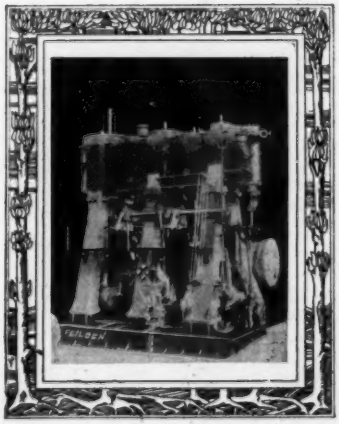
result can be attained better by scientific arrangement of pipes than by bad arrangement of pipes and subsequent fitting of various patented separators, although there is no objection to the use of these after it is quite certain that the pipe system is as perfect as it can be made. The separator will come on duty when the engines have been standing and are first started, or when there is an accumulation of water from other causes.

This matter is of the greatest importance, and it cannot be doubted that breakdowns, delays, and even total losses of ships, have occurred, and will again occur, from water in steam pipes. The subject is one, therefore, well worth patient study.

By the courtesy of Professor Alexander B. W. Kennedy, we are enabled to publish drawings of two important electric light central station installations, for which he was consulting engineer. In the system designed by him provision is made for expansion of pipes, for drainage of pipes, and for taking steam from any boiler to any engine by duplicate route, so that the breakdown repairs, or other work which may affect one pipe route, will not affect the supply of current. By what is called a travelling pipe a ring supply of steam is secured.

As the installation grows, this travelling pipe is always fixed outside and beyond the last new addition to engines or boilers.

Stephen. H. Terry.



Methods of Estimating the Power of Ships.

By W. H. ATHERTON, M.Sc.

AFTER a grammar school education, Mr. W. H. ATHERTON commenced his business career in the year 1883 in the textile machinery works of Messrs. Brooks & Doxey, Ltd., Manchester. From 1886 to 1889 he was with Messrs. Craven Bros., Ltd., machine tool and crane makers; and subsequently for six months in the drawing office of Messrs. Henry Wren & Co.

Leaving Manchester in 1890 he entered the service of Messrs. Sir W. G. Armstrong, Whitworth & Co., Ltd., Newcastle-on-Tyne, and turned his attention to the serious study of warship machinery. His scientific education up to 1893 had been gained mainly by evening studies; but in that year he became a day student of the Durham College of Science, Newcastle-on-Tyne, and spent some years in the study of languages, pure and applied science, and marine engineering. He also attended four courses of lectures at the Royal College of Science, London. In due time he graduated as B.Sc., and three years later as M.Sc.

In 1897 he obtained an appointment with Messrs. Mather & Platt, Ltd., Manchester, where he has since been engaged upon the equipment of electric generating stations. In the same year he also became an evening Lecturer at the Manchester Municipal Technical School, of which for seven sessions he was an evening student.

He is a Whitworth Exhibitioner, a Royal Exhibitioner in Science, a member of the North-East Coast Institution of Engineers and Shipbuilders, a member of the Manchester Association of Engineers, and the author of numerous published articles and papers on engineering subjects.

IN the present and succeeding articles it is intended to discuss briefly the more important methods in use of estimating the engine-power required to propel a proposed ship at a specified speed, and to illustrate their application. The methods selected for consideration are the following:—

(1) The Admiralty formula method.
(2) The method of comparison with a model or type ship at corresponding speeds.
(3) Kirk's analysis.
(4) The independent estimate method.

No method is absolutely exact, though it is possible to estimate the power required with a probable error not exceeding 5 per cent. This degree of approximation is sufficient in practice.

I.—THE OLD ADMIRALTY METHOD.

The old-established and still much used Admiralty formula is

$$P = \frac{V^3 \times D^{\frac{2}{3}}}{C},$$

where

P is the collective indicated-horse-power of the engines,
V is the intended speed of the ship in knots of 6,080 ft. per hour,
D is the displacement of the ship in tons of 2,240 lbs.,
C is the displacement coefficient, also misnamed the coefficient of performance—an experimental factor deduced from the speed trials of existing ships of similar type to the proposed ship.

The value of C, it is important to note, is not constant, but varies through a limited range with every ship and with different speeds of the same ship, as seen in Fig. 1. Its value, however, seldom exceeds 300, and seldom falls below 150, so that the range of variation is about 100 per cent. Some writers are still, unhappily, under the old delusion that, of several ships under comparison, the one which gives the highest value of C is in some vague sense the most

efficient, however much the ships may differ in type.

The Admiralty formula may be written also in the alternative form—

$$\log P = 3 \log V + \tfrac{2}{3} \log D - \log C,$$

which is more convenient for logarithmic computation.

EXAMPLES :—

(1) To calculate the indicated horse-power required to drive a 14,000-ton battle-ship at 18 knots speed.

Trials of battle-ships show that a suitable value of C is about 240; hence

$$\log P = 3 \log 18 + \tfrac{2}{3} \log 14{,}000 - \log 240$$
$$= 3 \times 1{\cdot}2553 + \tfrac{2}{3} \times 4{\cdot}1461 - 2{\cdot}3802$$
$$= 4{\cdot}1498$$

$\therefore P = 14{,}120$, the required power.

(2) For a 3000-ton cruiser at 23 knots, a suitable value of C is about 160; hence the power required is something of the order of

$$\frac{23^3 \times 3000^{\frac{2}{3}}}{160} = 15{,}820 \text{ i.h.p.}$$

(3) For a bluff 5000-ton cargo boat at 10 knots, C approximates to 260, consequently

$$P = \frac{12^3 \times 5000^{\frac{2}{3}}}{260} = 1944 \text{ i.h.p.}$$

It is always advisable to allow at least 5 per cent. margin of power above that estimated.

The advantages of the Admiralty method are simplicity and quickness—two very weighty practical considerations. A practical objection is, that much data and experience are necessary to enable the estimator to choose a suitable value of C; and a no less important scientific objection is that the formula is based on false or, at any rate, very rough assumptions, as will appear later on.

Sir W. H. White, in his "Manual of Naval Architecture," interestingly remarks:

"The difficult part of the work in practice lies in the selection, from available data, of exemplar ships most nearly resembling the new design, in order that the appropriate coefficients may be obtained. In making this selection it is necessary to compare carefully the fineness of form, the dimensions, the lengths of entrance and run in proportion to the maximum speeds, and some other particulars of the new ship and the completed ships; and to make allowances for greater or less fineness of form, differences in the frictional resistance, or any other matter affecting the speed under steam. In the Royal Navy, for the greater number of classes, little difficulty is experienced in discovering suitable examples; but when entirely new conditions are introduced it is not possible to proceed with equal certainty, and then it becomes necessary, in proceeding by this comparative method, to allow a considerable margin of power and speed."

DEDUCTION OF THE ADMIRALTY FORMULA.

The formula is based on the following assumptions :—

(1) That the total fluid resistance (R) to the motion of any ship varies as the square of the ship's speed (V).

(2) That the same resistance varies as the ship's immersed or wetted surface (S).

(3) That the efficiency of propulsion is constant, the efficiency being defined as the ratio of the effective horse-power (P_e) usefully employed in propelling the ship to the indicated horse-power (P) of the engines.

(4) That the ships compared are *similar*—*i.e.*, differ in *scale* only, and not in shape.

To what extent these assumptions or hypotheses are unjustifiable will be discussed presently; meanwhile the formula will be deduced from them.

By hypotheses (1) and (2) we have

$$R \text{ varies as } V^2 \times S.$$

Multiplying by V, we get

$$R \times V \text{ varies as } V^3 \times S.$$

But effective horse-power

$$= \frac{\text{resistance in lbs.} \times \text{speed in feet per min.}}{33{,}000}$$

so that $R \times V$ measures, in certain units, the effective power.

$$\therefore P_e \text{ varies as } V^3 \times S.$$

Now, by hypothesis (3), P varies as P_e.

$$\therefore P \text{ varies as } V^3 \times S,$$
$$\text{or } P = c V^3 S \quad . \quad . \quad . \quad (1)$$

where c is some constant. This result (1) may be used as it stands, by giving suitable values to c in different cases; but it is better to express the wetted surface in terms of the more convenient and better-known magnitude displacement. This is done in the following manner:—It is a well-known geometrical fact that the surfaces of similar solids are propor-

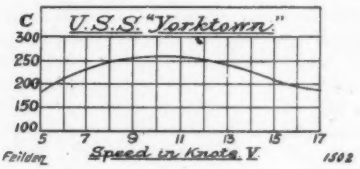


FIG. 1.—CURVE SHOWING DISPLACEMENT COEFFICIENT WITH VARYING RATES OF SPEED.

tional to the squares of their corresponding linear dimensions, such as their lengths (L). Hence, for similar ships, as supposed in hyp. (4) above—

S varies as L^2, that is, varies as $(L^3)^{\frac{2}{3}}$.

But volume varies as L^3,

$\therefore$ S varies as volume$^{\frac{2}{3}}$ . . . . (2)

Again, since the mass of a body is equal to its volume multiplied by its mean density, the displacement of a ship is proportional to the immersed volume or cubic displacement; or

D varies as volume,

$\therefore$ $D^{\frac{2}{3}}$ varies as volume$^{\frac{2}{3}}$.

Hence, from result (2),

$D^{\frac{2}{3}}$ varies as S . . . (3)

so that wetted surface can be expressed in terms of displacement raised to the two-thirds power, or briefly—

the ratio $\frac{D^{\frac{2}{3}}}{S}$ is constant.

Substituting $C_1 D^{\frac{2}{3}}$ for $c\,S$ in result (1) we get

$$P = C_1 \times V^3 \times D^{\frac{2}{3}}.$$

Putting $\frac{1}{C}$ for C_1 we finally obtain

$$P = \frac{V^3 \times D^{\frac{2}{3}}}{C},$$

which is the required Admiralty formula. It will be noticed that C is constant for similar ships, compared at corresponding speeds, but not otherwise.

EXAMINATION OF THE HYPOTHESES.

(1) That the total resistance of a ship varies as the square of the speed is only approximately true for a very limited range of speed. The tank experiments of the late Dr. William Froude showed conclusively that the correct index of variation is much more nearly 1·83 than 2, for a long newly-painted surface like that of a ship. So that, at very low speeds, frictional resistance varies as $V^{1\cdot83}$, and all other resistances are relatively insignificant.

As the speed increases, however, the energy expended in the formation of *waves* becomes a serious item, as clearly appears from Fig. 2, which shows the distribution of power (according to Mr. W. D. Taylor) in the case of the U.S. gunboat *Yorktown*. Thus wave-making resistance must be superadded to the frictional or skin resistance, which continues to follow the law of increase above stated. Now, the law of variation of wave resistance is quite different from the law of

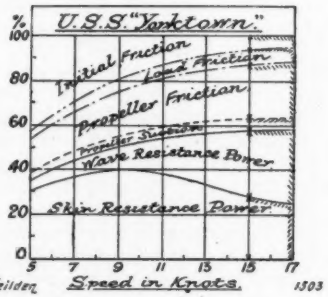


FIG. 2.—CURVES SHOWING DISTRIBUTION OF POWER AT VARYING SPEEDS.

frictional resistance. In fact, for speeds not exceeding 10 knots, in the case of a ship 100 ft. long, and 20 knots in the case of a 400-ft. ship, the wave-resistance varies approximately as the fourth power of the speed, and the horse-power expended in overcoming that resistance as the fifth power of the speed. When vessels are driven above speeds appropriate to their lengths, as torpedo boats always are, the curve of wave-resistance becomes definitely periodic in character; that is to say, it shows well-defined "humps and hollows," as Froude termed them. Clearly, then, the assumption that the total resistance of a ship varies as the

square of the speed is, for modern high-speed ships, wholly unjustifiable. The fact is, the Admiralty formula ignores wave-making resistance altogether, and is therefore essentially a slow-speed formula.

(2) The hypothesis that the total resistance of a ship is proportional to the number of square feet of surface in contact with the water, is justifiable only when the proviso is made that the speed of the ship must be so low that wave-making resistance is negligible. In the derivation of the Admiralty formula, no account was taken of the *shape* of the vessel. But it is well known that, at high speeds, a fine ship, with long entrance and run and short parallel middle body is much easier to drive than a bluff ship of the tramp type. Consequently it is not true that the power required to drive ships of all shapes and sizes is directly proportional to the extent of wetted surface.

(3) The hypothesis that the efficiency of propulsion is constant at all powers is far from true. The propulsive efficiency of a ship is the product of the mechanical efficiency of the engines and shafting into the efficiency of the propellers. But not all propellers are equally efficient, and certainly marine engines differ considerably in mechanical efficiency according to their type, their condition, and the proportion of full power at which they are run. A long-stroke engine is, as a rule, more efficient than a short-stroke engine of the same power; and of course a well-lubricated engine works with less friction than one imperfectly lubricated, either with inferior oil or an inadequate supply of suitable oil. Small slide-valves and valve-travels are also conducive to high mechanical efficiency. The condition of the piston rings, rods, rod packings, slides, and main bearings has likewise a marked influence on the mechanical efficiency; and the alignment of the shafting is a matter of some importance in reducing friction. The variety of methods of driving air and other pumps further complicates the question. Thus, to secure anything like a fair comparison, the ships compared must be fitted with engines of the same type, worked at about the same referred mean pressure, and fitted with similar propellers. At full power, the efficiency of different engines varies from ·8 to ·9, and of various propellers from ·58 to ·68. The combined efficiency of the propelling mechanism will therefore vary from ·464 to ·612 approximately, and at very low powers it may sink as low as ·25.

(4) The important hypothesis that the ships compared are *similar*, or built on the same model, should not be forgotten. It has not always been clearly recognised that the Admiralty formula is strictly applicable to the estimation of the engine-power of a proposed ship only when the latter is intended to be built on similar lines to a ship that has already been carefully tried on the measured mile, and the value of the coefficient of performance C deduced as in the following example:—

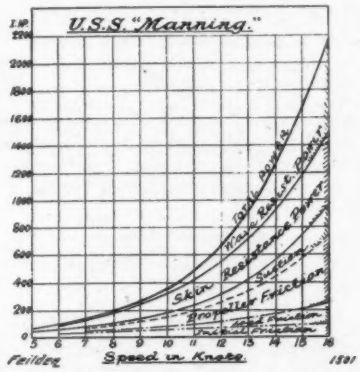


FIG. 3.—SPEED AND POWER CURVES OF U.S.S. "MANNING."

The Italian cruiser *Piemonte*, built at Elswick, has a displacement of 2,500 tons, and on the measured mile trials it required 12,980 i.h.p. to propel her at 22·3 knots, the engines being four-crank triples. For this ship, then, at the speed stated

$$C = \frac{V^3 \times D^{\frac{2}{3}}}{P} = \frac{22{\cdot}3^3 \times 2500^{\frac{2}{3}}}{12{,}980}$$

$\therefore \log C = 3 \log 22{\cdot}3 + \frac{2}{3} \log 2500 - \log 12980$
$= 2{\cdot}1967$, by the use of tables;
and therefore $C = 157{\cdot}3$.

In this way suitable values of C for all types of ships are obtained and tabulated

for future use. In every case it is advisable also to calculate the value of the "block coefficient" or so-called coefficient of fineness, thus :—

$$C_f = \frac{35 \times \text{Displacement}}{\text{Length} \times \text{Breadth} \times \text{Draught}}$$

$$= \frac{35 \times 2500}{325 \times 38 \times 15} = 0{\cdot}472,$$

as well as the value of the "prismatic coefficient"

$$\frac{35 \times \text{Displacement}}{\text{Length} \times \text{Immersed Midship Section}}.$$

II.—THE METHOD OF COMPARISON WITH A MODEL SHIP.

An important relation exists between the powers required to drive similar ships at certain speeds related in a particular way to their lengths, these speeds being known as *corresponding speeds*. If, for instance, we are comparing a 300-ft. ship with a 12-ft. model, and the intended speed of the ship is 20 knots, then the corresponding speed V of the model is given by the relation

$$\frac{20}{V} = \sqrt{\frac{300}{12}} = \sqrt{25} = 5,$$

so that

$$V = 20 \div 5 = 4 \text{ knots}.$$

Thus, corresponding speeds of similar ships are proportional to the square roots of the lengths. The relation does not hold for dissimilar ships.

Again, if a proposed ship 400 ft. long is intended to steam at 18 knots, and is to be similar to a type-ship 300 ft. long, then the corresponding speed V of the latter will be such that

$$\frac{18}{V} = \sqrt{\frac{400}{300}} = 1{\cdot}153,$$

therefore

$$V = 15{\cdot}6 \text{ knots};$$

and this is the speed at which the comparison of powers must be made.

Having thus found the corresponding speed of the type-ship, which has been tried on the measured mile (or in an experimental tank, in the case of a small model), the next step is to read off from a curve the power P required to drive the type-ship at that speed, and then the indicated horse-power needed to drive the proposed ship will be

$$P \times r^{\frac{7}{2}}$$

where r is the ratio

$$\frac{\text{length of proposed ship}}{\text{length of type-ship}}.$$

Before proving this rule an instance of its use is desirable.

EXAMPLE.—The speed and power curves of the United States steamship *Manning* are given in Fig. 3. The length of the ship between perpendiculars is 188 ft. It is required to find the power required to drive a similar ship 230 ft. long at 17 knots. The method is as follows :—

$$\text{Length ratio } (r) = \frac{230}{188} = 1{\cdot}223.$$

The speed of the type-ship *Manning*, corresponding to 17 knots of the proposed ship, is therefore

$$\frac{17}{\sqrt{1{\cdot}223}} = 15{\cdot}35 \text{ knots}.$$

Referring now to the *Manning's* power curve, we find that 1900 h.p. was developed by the engines at this speed; hence the horse-power required to be developed by the engines of the proposed 230-ft. ship will be

$$1900 \times 1{\cdot}223^{\frac{7}{2}}.$$

To complete the calculation it will be necessary to use a table of logarithms or its equivalent, thus—

$$\log\ 1900 = 3{\cdot}2788$$
$$\tfrac{7}{2} \log 1{\cdot}223 = \tfrac{7}{2} \times {\cdot}0874 = 0{\cdot}3059$$
$$3{\cdot}5847$$

The number corresponding to this logarithm is 3845, which is therefore the indicated horse-power sought.

The method here exemplified is strictly applicable only in respect of the power required to overcome the *wave-making* resistance of the ship, for the frictional resistance does not follow the law of comparison, and should therefore be calculated independently when the highest accuracy is aimed at. In working from a model ship only 10 ft. to 20 ft. long, this should always be done; but when the ships compared do not differ greatly in size it is sufficiently approximate to proceed as directed above.

It is not universally known that it was the late Mr. William Denny who introduced, in the year 1870, the valuable practice of conducting progressive speed trials on the measured mile, instead of merely making runs at full speed, as was formerly the custom. In his first published paper—"The Difficulties of Speed Calculations"—read before the Institution of Engineers and Shipbuilders in Scotland in the spring of 1875, he strenuously urged the desirability of having all steamers tried progressively. The same year Mr. Denny read a paper before the British Association on "The Trials of Screw Steamships," setting forth similar views. Shortly afterwards he wrote an interesting letter to a friend, saying: "Froude backed me well, and said it was simply absurd to call any other system of trial than the progressive system a fair trial of a ship's work on the mile. Anyway, I shall not rest till I get the system acknowledged and generally adopted. Froude will very likely press it on the Admiralty."

Proof of the $r^{\frac{7}{2}}$ Formula.—It will now be proper to show the truth of the formula made use of above, namely

$$P = p\, r^{\frac{7}{2}},$$

where

P = indicated horse-power required to drive a proposed ship at V knots,
p = power of model or type ship,
r = length ratio.

Since

$$\frac{V}{v} = \sqrt{\frac{L}{l}} = r^{\frac{1}{2}}$$

$$\therefore \left(\frac{V}{v}\right)^3 = r^{\frac{3}{2}} \quad . \quad . \quad . \quad (1)$$

Also, since

$$\frac{D}{d} = \frac{L^3}{l^3} = r^3,$$

where d is the displacement of the type-ship, and l its length,

$$\therefore \left(\frac{D}{d}\right)^{\frac{2}{3}} = (r^3)^{\frac{2}{3}} = r^2 \quad . \quad . \quad (2)$$

Again, since

$$P = \frac{V^3 D^{\frac{2}{3}}}{C}$$

where C is constant for corresponding speeds of similar ships,

$$\therefore \frac{P}{p} = \frac{V^3 D^{\frac{2}{3}}}{v^3 d^{\frac{2}{3}}} = \left(\frac{V}{v}\right)^3 \times \left(\frac{D}{d}\right)^{\frac{2}{3}}$$

Hence, from (1) and (2)

$$\frac{P}{p} = r^{\frac{3}{2}} \times r^2 = r^{\frac{3}{2}+2} = r^{\frac{7}{2}}$$

$$\therefore P = p\, r^{\frac{7}{2}}$$

the required formula.

An Alternative.—A slight variation from the last-described method of powering a ship is to draw a curve of coefficients of performance for the type-ship, and then use the value of C appropriate to the corresponding speed of the model. The result arrived at should be the same. In case a single value of C only is required, it is sufficient to calculate the desired value without drawing the curve. Thus, in the case of the above-mentioned *Manning*, of 1000 tons displacement, the value of the Admiralty displacement coefficient at a speed of 15·35 knots is

$$C = \frac{V^3 \times D^{\frac{2}{3}}}{P} = \frac{15{\cdot}35^3 \times 1000^{\frac{2}{3}}}{1900} = 191.$$

The displacement of the proposed ship not being given, it is necessary to find it from the law that the displacement of similar ships varies as the cubes of their lengths. Hence the displacement of a 230-ft. ship will be

$$\left(\frac{230}{188}\right)^3 \times 1{,}000 \text{ tons} = 1{,}830 \text{ tons.}$$

Then the power of the proposed ship at 17 knots will be

$$\frac{V^3 \times D^{\frac{2}{3}}}{C} = \frac{17^3 \times 1830^{\frac{2}{3}}}{191} = 3850 \text{ i.h.p.},$$

which is practically the same result as before. This alternative method is obviously more indirect and laborious than the $r^{\frac{7}{2}}$ method, and also demands more data.

To facilitate the practical application of the method of comparison with a type-ship it is advantageous to throw all one's available data into the form of standard curves, drawn for a standard displacement of, say, 10,000 tons; but the method of constructing and applying such curves is beyond the scope of the present article.

Referring to the method of approximating to the engine-power required in a new ship by means of model experiments, Sir W. H. White remarks, in his "Naval Architecture":—

"This method is much to be preferred when novel types of ships are to be built or unusual speeds attained. Unlike the first method, based upon coefficients of performance, it does not assume that the resistance varies as the square of the speed, which may be, and is often, very far from the truth. But it takes account of the actual resistance; and whatever may be the true law of its variation in terms of the speed, that law is represented in the result."

Objections to the method in question are that a costly experimental tank, elaborate measuring appliances, and a specially trained staff are indispensable; also that errors of small amount with the models become greatly magnified in passing to full-sized ships, seriously affecting the estimates of power.

The leading particulars of the two ships chiefly referred to in this article are given below:—

taken as proportional to the wetted surface. The wave-making resistance is not explicitly taken into account, though some allowance is implicitly made for it by varying the numerical coefficient. This method was introduced in the year 1880 by the late Dr. A. C. Kirk, of Glasgow, who was also famous in marine engineering as the designer of the first set of triple-expansion engines—namely, those fitted on board the *Propontis* in 1874.

Kirk's analysis consists of two parts, the first of which is a simple and rapid method of transforming or reducing a ship to an equivalent simple geometrical solid bounded by planes, and known as a Kirk's block model (Fig. 4). By this ingenious artifice the length of entrance and the mean angle of entrance of a given ship can be readily calculated, as also the approximate wetted surface, whereas the calculation of the *actual* wetted surface of a ship from the working plans is a long and tedious process.

TABLE SHOWING DETAILS IN CONSTRUCTION OF U.S.S. "YORKTOWN" AND "MANNING."

		YORKTOWN.	MANNING.
1. Service		War	War
2. Displacement	tons	1,680	1,000
3. Length between perp.	feet	226	188
4. Breadth (extreme)	,,	36	32·83
5. Draught (mean)	,,	13	12·33
6. Length ÷ breadth		6·28	5·72
7. Block coefficient		·555	·459
8. Wetted surface	sq. ft.	10,840	7,270
9. Highest speed on trial	knots	17	16
10. Revolutions per minute		165	152
11. Number of propellers		2	1
12. Diameter of propeller	feet	10·5	11
13. Pitch of propeller	,,	12·5	12·083
14. Cylinders of engines	inches	(22, 31, 50) 30	(25, 37½, 56¼) 30
15. Full power	i.h.p.	3,694 Collective	2,200

III. KIRK'S ANALYSIS.

Kirk's method of estimating the engine power needed to drive a proposed ship at a specified speed is a modification of the Admiralty formula method, applicable to either similar or dissimilar ships of moderate speed. Instead of the total resistance of the ship being assumed to vary as the two-thirds power of the displacement, it is

A Kirk's block has the same length, mean draught, and midship area as the immersed part of the corresponding ship, and also the same volume or displacement. But the breadth of the block is less than the beam of the ship. In reckoning the effective draught, the keel, if any, must be deducted from the ship's actual draught; but it happens very con-

veniently that most recent ships are built without a central projecting keel. The top of the block is regarded as

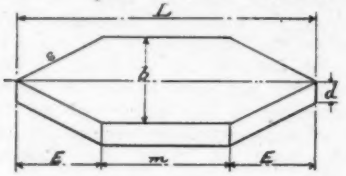


FIG. 4.—KIRK'S BLOCK MODEL FOR ANALYSING ENGINE POWER REQUIRED FOR SHIPS.

floating level with the surface of smooth water. In every Kirk's block-model, the length of entrance, or "fore-body" is equal to the length of the run, or "after-body," although this may not always be true of the actual ship.

The second part of Kirk's analysis is the simple power formula

$$P = \frac{k \times S \times V^3}{100{,}000},$$

P being the indicated horse-power required to drive a ship having S square feet of block surface at a speed of V knots, and k a coefficient or number varying in value with the speed of the ship, and being also different for ships of different form. Roughly speaking, the value of k is 6 for short, broad ships at full speed, 5 for ordinary cargo boats, and 4 for fine-lined ships of high propulsive efficiency, and free from fouling matter. These values, however, are too rough to be of much service, as will appear from an example further on.

Kirk's method is, perhaps, rather more accurate than the Admiralty method, unless the trial data of a precisely similar ship to that proposed happen to be available; but it is also a little more laborious. Both methods are based on the same assumptions that resistance varies as the square of the speed, and that the efficiency of propulsion is constant at all speeds of a given ship. As these are nearly true only for a certain range of power, the value of k for any particular ship necessarily changes with the speed. Whenever possible, therefore, it is best to choose a value of k deduced from the trials of a ship similar in type to the proposed ship, and also to make the comparison at "corresponding speeds."

The truth is that, for a given ship, a reciprocal relation exists between the values of Kirk's coefficient k and the Admiralty coefficient C. For since the result given by each formula should be the same, it necessarily follows that

$$\frac{D^{\frac{2}{3}} V^3}{C} = \frac{k S V^3}{10^5}$$

On removing the common term and multiplying across this equation becomes

$$C k S = 10^5 D^{\frac{2}{3}},$$

$$\text{therefore } C k = \frac{10^5 D^{\frac{2}{3}}}{S}.$$

Now, for any one ship, the displacement D and the wetted surface S of the block are constants, so that

$$C k = \text{constant, or } C \propto \frac{1}{k}$$

Accordingly, as the value of the Admiralty coefficient C increases with change of speed, the value of Kirk's coefficient k will diminish, and conversely.

To illustrate this important point, take the case of the American 1680-ton gunboat *Yorktown*, whose block surface is 10,470 sq. ft., as shown in a subsequent calculation. Using the last formula,

$$C k = \frac{10^5 \times 1680^{\frac{2}{3}}}{10{,}470} = 1350.$$

In the following table are given the powers recorded on the measured-mile trials of this ship for six different speeds. From these trial results I have deduced the corresponding values of the Admiralty coefficient C, and then found the parallel values of k by dividing 1350 by the proper value of C. Thus, at a speed of 10 knots,

$$k = 1350 \div 264 = 5{\cdot}11.$$

It will be noticed that k is far from being constant in value at all speeds.

Speed of ship in knots.	Indicated horse-power of engines.	$C \times k$.	Admiralty coefficient, C.	Kirk's coefficient, k.
5	96	1350	184	7·34
8	286	,,	253	5·34
10	536	,,	264	5·11
12	986	,,	247	5·47
15	2310	,,	207	6·52
17	3690	,,	188	7·18

In Fig. 5 the above values of C and k have been plotted on a speed base, and the spots joined up to form fair curves. At any particular speed the product of the two ordinates is constant.

EXAMPLE.—A modern cargo steamer of 8,704 tons load displacement is 352 ft. long between perpendiculars, 49 ft. beam, and has a mean draught of 22·61 ft. The immersed mid-area is 1076 sq. ft. The block model and the power needed to drive the ship at 10 knots are required. (See Figs. 4 and 6.)

(1) The first step is to find the breadth b of the block from the relation.

Breadth of block × draught = mid-area of ship,
$\therefore b \times 22{\cdot}61$ ft. $= 1076$ sq. ft.,
$\therefore b = 47{\cdot}6$ ft.

Thus the block is 1·4 ft. narrower than the ship.

(2) The length of entrance E is found from the fundamental relation.

Volume of block = immersed volume of ship
= 35 × displacement,

since a ton of sea-water has a volume of 35 cub. ft. Now the two wedge-shaped ends of a block model have together the same volume as a rectangular block of length E, breadth b, and depth d, so that the total volume of a Kirk's block evidently equals that of a prism whose length is $L-E$, and whose cross-section is the immersed mid-area M of the ship; hence

$(352 - E)\ 1076 = 35 \times 8704,$
$\therefore\ 352 - E = 283,$ and $E = 69$ ft.

This is the length of the entrance and of the run of the block-model, and approximately of the ship also. The block can now be drawn to scale in the conventional manner shown by Fig. 6, a cross-section being also given.

(3) To find the length of the sloping side s, we apply Euclid's well-known proposition, I. 47, thus—

$$s^2 = E^2 + (\tfrac{1}{2}b)^2 = 69^2 + 23{\cdot}8^2$$
$$= 4761 + 566 = 5327,$$

therefore $s = 73$ feet.

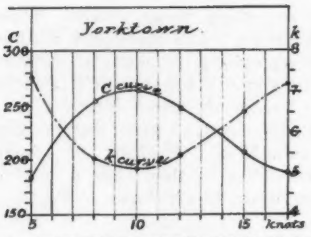


FIG. 5.—CURVES SHOWING THE VARIATION OF THE ADMIRALTY AND KIRK'S COEFFICIENTS.

(4) The perimeter of the block is four times the length of the sloping side *plus* twice the length of the parallel middle body, that is

$$p = (4 \times 73 \text{ ft.}) + (2 \times 214 \text{ ft.})$$
$$= 292 + 428 = 720 \text{ ft.}$$

(5) The wetted surface of the block is the bottom surface *plus* the side surface, that is

$$S = (L - E)b + p \times a$$
$$= (283 \text{ ft.} \times 47{\cdot}6 \text{ ft.}) + (720 \text{ ft.} \times 22{\cdot}61 \text{ ft.})$$
$$= 13{,}450 + 16{,}300 = 29{,}750 \text{ sq. ft.}$$

(6) By Kirk's formula, the power required to drive this ship at 10 knots will be

$$P = \frac{k \times S \times V^3}{100{,}000}$$
$$= \frac{5{\cdot}5 \times 29{,}750 \times 1000}{100{,}000} = 1640 \text{ I.H.P.}$$

Also by the Admiralty formula

$$P = V^3 \times D^{\frac{2}{3}} \div C$$

the indicated horse-power works out to 1690 when $C = 250$, and to 1630 when

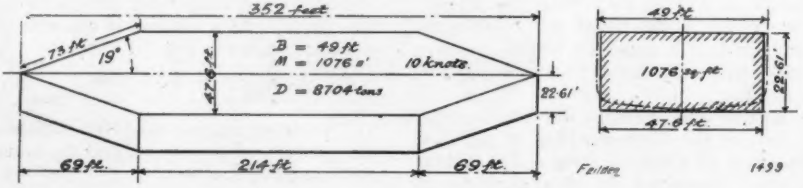


FIG. 6.—BLOCK MODEL AND MIDSHIP SECTION OF A LARGE BOAT.

$C = 260$, these being suitable values for cargo boats. The agreement is therefore close enough for all practical purposes.

The angle of entrance of a block-model is a feature of some interest. It may either be measured from the block-model or calculated. If half this angle be denoted by θ, then $\tan \theta = \frac{1}{2}b \div E$. Thus, in the block shown in Fig. 6

$$\tan \theta = \frac{23{\cdot}8}{69} = {\cdot}3455.$$

On referring to a table of natural tangents, we find that the angle whose tangent has this value is about 19°; so that the angle of entrance in this case is 38°, denoting a bluff ship adapted for slow speeds only. Referring to Fig. 4, there is some uncertainty as to whether θ or 2θ should be called the angle of entrance. Kirk calls θ the *half* angle of entrance, and this practice I have here followed.

The wetted surface of a block-model is usually *greater* than the true wetted surface of the ship, the percentage of variation depending on the type of the ship. In the case of very full vessels with a high block coefficient the excess is from 2 to 3 per cent. For most merchant steamers the excess appears to be from 3 to 5 per cent., and for fine ships from 6 to 8 per cent. For exceptionally fine steamers, with hollow water-lines, the excess is as much as 8 to 11 per cent. On the other hand, Kirk's block gives about 3 per cent. too *small* a wetted surface in the case of such abnormal vessels as stern-wheel steamers, having a length of about four times the beam only, as well as a large block coefficient, viz., ·83 or more. These variations from the true surface are rather greater than those stated by Dr. Kirk in his original paper in the Transactions of the Institution of Naval Architects for 1880, the figures here given being based on information contained in a paper by Mr. A. Denny, read before the same Institution in the year 1894.

As a second example, the block calculations of the *Yorktown* (Fig. 7) will now be given in a concise form. The actual powers developed by this gunboat at various speeds have already been given, and also, in Fig. 5, a curve of variation of Kirk's coefficient k.

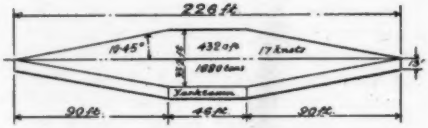


FIG. 7.—BLOCK MODEL OF THE "YORKTOWN."

(1)
$$bd = M, \therefore b \times 13 \text{ ft.} = 432 \text{ sq. ft.}, \therefore b = 33{\cdot}2 \text{ ft.}$$

(2)
$$(L - E)M = 35D, \therefore (226 - E)432 = 35 \times 1680,$$
$$\therefore \quad 226 - E = 136, \quad \therefore E = 90 \text{ ft.}$$

(3)
$$s^2 = E^2 + (\tfrac{1}{2}b)^2 = 90^2 + 16{\cdot}6^2 = 8376,$$
$$\therefore s = 91{\cdot}5 \text{ ft.}$$

(4)
$$p = 4s + 2m = 4 \times 91{\cdot}5 + 2 \times 46$$
$$= 366 + 92 = 458 \text{ ft.}$$

(5)
$$S = (L - E)b + pd = (136 \times 33{\cdot}2) + (458 \times 13)$$
$$= 4515 + 5955 = 10{,}470 \text{ sq. ft.}$$

The actual wetted surface of the *Yorktown* is stated to be 10,840 sq. ft. If this be true, which is improbable, the *deficiency* of the block surface is 370 sq. ft., or 3·4 per cent.

(6)
$$\tan \theta = \frac{b}{2E} = \frac{33{\cdot}2}{180} = {\cdot}1844.$$

$$\therefore \theta = 10{\cdot}45°, \text{ and } 2\theta = 20{\cdot}9°.$$

This angle corresponds to a distinctly fine ship.

Some estimators use a modification of Kirk's method, based on Rankine's augmented surface method, the latter being impracticable in its original form. In this the expression $1 + 4 \sin^2 \theta$ is termed the coefficient of augmentation. It is a factor which takes account of the fineness of the ship, being greater for full than for fine ships. Thus, in the case of the block shown in Fig. 6,

$$\sin \theta = \sin 19° = {\cdot}3256,$$
$$\text{and} \quad 1 + \sin^2 \theta = 1 + 4 \times {\cdot}106 = 1{\cdot}424.$$

The so-called augmented block surface is the product of this factor and the actual block surface, thus

$$1{\cdot}424 \times 29{,}750 = 42{,}400 \text{ sq. ft.}$$

Rankine's power formula may then be applied, viz.,

$$P = \frac{V^3 \times A}{C},$$

where V knots is the intended speed of the ship, A sq. ft. is the augmented surface of the block, and C is a coefficient deduced from speed trials, and approximating to 20,000.

Fig. 8 shows the block-model of a recent combined passenger and cargo steamer of 13,810 tons displacement, designed for a speed of about 13 knots. The draught of 27 ft. 3 in. is noteworthy, being surpassed by very few ships. The draught of the *Campania*, for instance, is only 23 ft.

A comparison of the various examples of block-models illustrated will give some idea of the variation in the general proportions of steamships designed for different services.

In a future article I intend to deal with the process of estimating the power necessary to propel a steamship in accordance with the more fundamental and instructive method of first calculating the several components of resistance, then deducing the *effective* horse-power, and finally arriving at the *indicated* horse-power by dividing the former by the probable efficiency of propulsion.

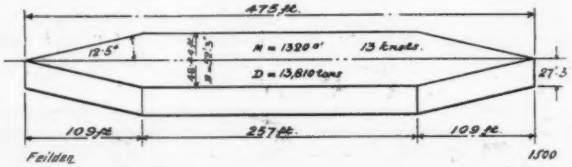


FIG. 8.—BLOCK MODEL OF A MIXED TRAFFIC STEAMER.

W. H. Atherton.

Constant Spring Waterworks.

By W. ROGER SANGUINETTI.

CONSTANT Spring Waterworks are situated seven miles inland from Kingston, Jamaica, and are at an elevation of 730 ft. above sea level.

tunnel is 1,480 ft. long and is now used for the waterworks, the Government having acquired it and also the land on both sides of the river from the intake to the head.

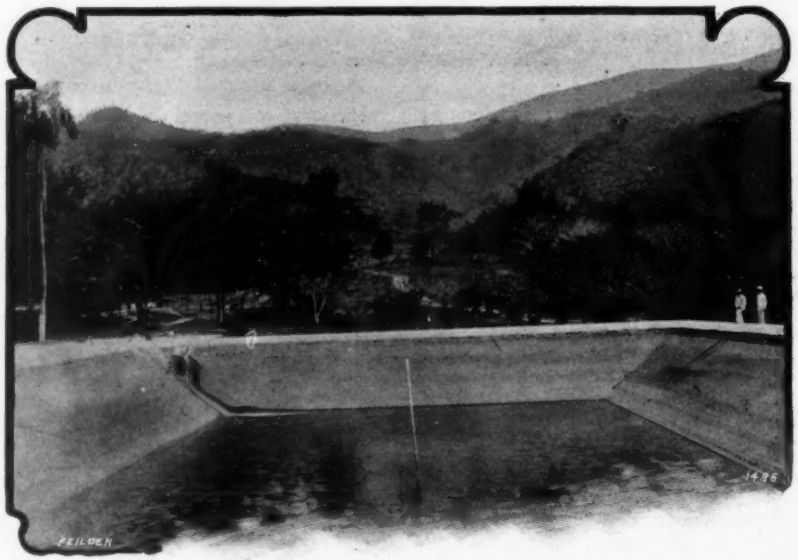


FIG. 1.—CONSTANT SPRING WATERWORKS, GENERAL VIEW OF 1,500,000 GALLON RESERVOIR.

From the site of the waterworks a grand view is obtained of the town and harbour of Kingston and the Liguanæ Plains, with the Palisadoes and Port Royal in the distance.

In the palmy days of the sugar industry Constant Spring was a large sugar estate, and the water which worked the estate machinery was brought from the Wag Water River through a hill by means of a tunnel which had been constructed during the Spanish occupation. This

From the tunnel the water used to flow through a natural valley for a distance of 29 chains, where a very fine masonry dam was constructed, and from the dam to the works the water went along a masonry gutter, and a fine stone aqueduct some 16 chains long and which at the water-wheel is about 20 feet high. The gutter is still in use, but the aqueduct has been idle for many years.

The tunnel was recently partly reconstructed, as it was not straight, nor was

the gradient uniform, which resulted in frequent damming up; the brickwork also, with which a great part of the tunnel was lined, had become unsafe. The tunnel was therefore straightened and lined with cement concrete in all places except where it passed through solid rock. It was built circular, having a diameter of 5 ft., the concrete being cast in segments outside and jointed with rich cement mortar.

From the outlet of the tunnel the water is now conducted by a 12-in. main to the gutter, which starts at the old dam. The gutter leads to a circular catch-pit, from which there are two 10-in. mains, leading to a small catch-pit at the head of the reservoirs. The head, from the circular catch-pit, is 142 ft., and the maximum supply is 4,430 gals. per minute.

These reservoirs have a capacity of 1,500,000 gals. each, and are of concrete on puddle, and 16 ft. deep at the centre. These reservoirs and the catch-pit are well represented in the two photographs, Figs. 1 and 2. The reservoirs had been constructed several years before, and supplied two mains, 9 ins. and 10 ins. respectively. This was altered, and the outlets from the reservoirs were led to an 18-in. pipe, from which there were 12-in. supplies to the filter beds.

The land on which the filter beds were built was rather uneven, and over 9,000 cubic yards of earth had to be excavated; at the extreme end of one of the filter beds was the head of a deep gully course, and a concrete retaining-wall had to be built. The wall was 15 ft. 3 ins. at the deepest point, and was 5 ft. thick to the level of the bottom of the filter beds, and the hollow thus enclosed was filled up with hand-built drystone packing and fine gravel, and sand was forced into the interstices of the stones with water.

The filter beds, of which there were four, were each 140 ft. by 60 ft., lying side by side; these were built of Portland cement concrete, mixed in the proportion of one part of cement, three parts of sharp

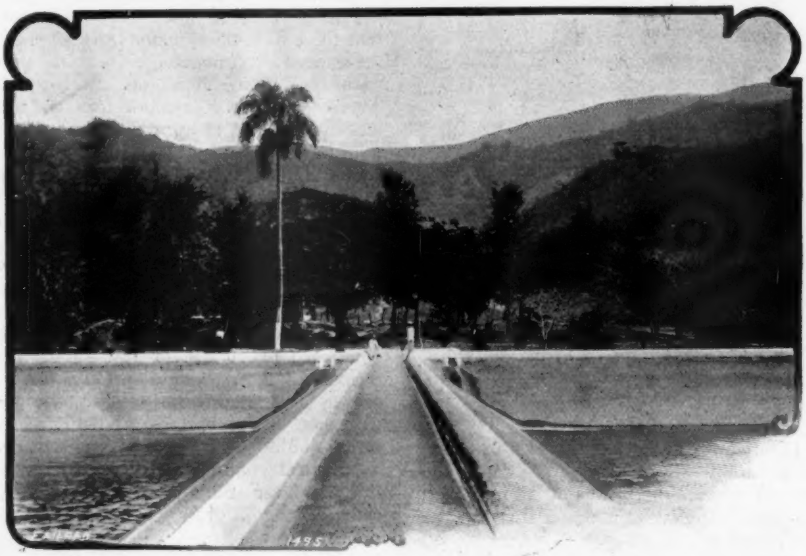


FIG. 2.—CONSTANT SPRING WATERWORKS, VIEW OF TWO RESERVOIRS AFTER ALTERATION, FILLED WITH WATER.

sand, and six parts of gravel or broken limestone, broken to pass through a 2-in. diameter ring. All faces that came in contact with the water were rendered ¾ in. thick with a very rich cement mortar, and afterwards washed over with neat cement milk.

The depth of these filters was 8 ft. 4 ins. at the sides, and 8 ft. 10 ins. at the centre. A section through the external wall is given, which also shows the arrangement of the filtering material.

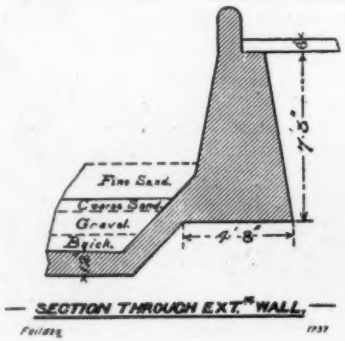


FIG. 3.—SECTION SHOWING ARRANGEMENT OF FILTERING MATERIAL.

The floor of the filters was 1 ft. thick, and had a fall of 1 in 40 towards the centre where there was a 14-in. drain leading to the outlet tank. All round the walls was a neat parapet 18 ins. high, and behind that a concrete pathway 4 ft. wide. The dividing walls were carried up to the level of the pathway. The earth was banked up all round behind the walls to the level of the foot-walk.

From the 14-in. drain the water passed into an outlet tank from each filter. These tanks were on the same level as the filters, and were 10 ft. square. From the wells there was a 12-in. pipe leading into the pure water tank, and also a 6-in. washout pipe which was connected to the 12-in. main; there was also a connection from this 12-in. pipe to the main, so that the pure water tank, could be cut out if required.

The pure water tank was a 16-sided polygon 50 ft. in diameter and 18 ft. deep. It was built of Portland cement concrete in the same proportions as the filter beds. The walls were 3 ft. 6ins. thick at the base with plumb faces and a batter of 1 in 12 at the bank. The earth was banked against the walls up to the top all round.

From the pure water tank was a 21-in. outlet pipe having three 12-in. branches —the centre branch supplied the 12-in. main and the other branches were reduced to 9 in. and 10 in. respectively, and supplied the mains of those sizes. It will be seen that there were three mains thus supplied; these were all connected close to the pure water tank where there was a valve well. There was also a connection from the outlet tanks to the 12-in. main, and in addition, in case of fire or any other cause for which filtered water was not required, there was a connection direct from the reservoir outlet to the 12-in. main. The pipe system and general arrangement of the tanks can be seen from the small plan. The water entered the filters at the inlets and percolated through the filtering material, which was composed of 18 ins. of fine sand, then 6 ins. of coarse sand on 12 ins. of gravel, graduated from fine at the top to coarse at the bottom, where it rested on a double layer of bricks so placed as to form channels to the centre 14-in. drain. Over the drain were concrete slabs resting on the bricks. This gave a depth of 4 ft. 4 ins. of water on the top of the sand, and fresh water could be passed in as fast as the filtration took place. Either filter could, of course, be worked separately, or all together. The 1 ft. 6 ins. of sand was to allow of thin layers of sand being taken off as it became foul. Between the reservoirs and the filters was a concrete platform or pavement, extending the full width of the filters, *i.e.* 240 ft. by 40 ft., on which sand washers were erected where clean sand could always be prepared and sized and used sand washed for future use.

As every special casting or special bend had to be ordered in England, and as the difference in level between the top of the reservoirs and the bottom of the pure

FIG. 4.—CONSTANT SPRING WATERWORKS: VIEW SHOWING NEGROES AT WORK IN THE FILTER BEDS.

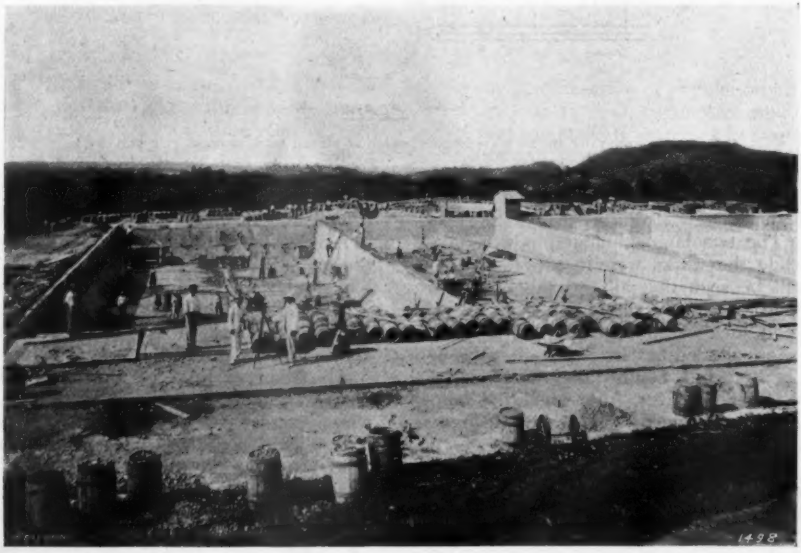
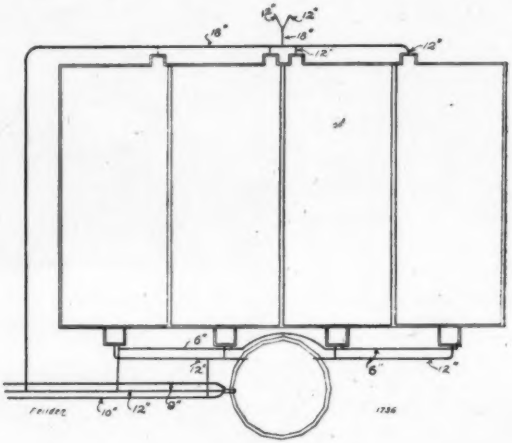


FIG. 5.—CONSTANT SPRING WATERWORKS: NEGROES CONSTRUCTING FILTER BEDS.

water tank was 32 ft., it will be seen that there would be a good many special pieces used, such as 12-in. off 18-in. tees, 12-in. tees, 6-in. off 12-in. tees, 18-in. to 12-in., 12-in. to 10-in., and 12-in. to 9-in. reducing pieces, besides many bends and some 30 valves. Great care had therefore to be taken in getting the pipes and valves that were built into the concrete at their proper levels and distances in order that the special pieces would fit when the connections came to be made.



— PLAN. —

FIG. 6.—CONSTANT SPRING WATERWORKS: PLAN OF FILTER BEDS SHOWING PIPE SYSTEM.

The two large photographs were taken while the works were in progress, and it will be seen that all the labourers were negroes. These photographs give a very good idea of the country. The tunnel before alluded to carries the water through the first hill behind the reservoirs, the Wag Water River, from which the supply is drawn, having its course between that hill and those seen in the distance.

The two small photos were taken some weeks afterwards, when the rendering of three of the filters was completed, and two of them were filled with water.

A great deal of gravel was used in the concrete, and this and the sand was procured from a dry river course that passed some 30 chains to the right in a valley about 200 ft. lower. All this material was brought up by labourers, chiefly women, who carried boxes or baskets full on their heads, and was put into empty cement barrels which will be seen in great numbers all round the works. This served the double purpose of fixing a task for the labourers, as it was all paid for by piece-work, and allowing the engineers to inspect all the material as it was brought up.

As Constant Spring supplies about half the water used in Kingston, the supply had to be maintained all the time the works were in progress, so that all pipe work necessitating the disconnection of existing mains had to be done at night.

The reduced level of the pure water tank was 698·264 ft. above sea level, at which a great part of Kingston is built; a very good pressure was therefore available in the town.

W. Roger Sanguinetti

The Town Refuse Problem, and its Relation to Steam Production.

By WILLIAM H. MAXWELL, Assoc.M.Inst.C.E.

MR. WM. H. MAXWELL received his early professional training in the West of England, where for several years he gained a very considerable practical experience in the City of Bath and Western Counties, in the course of the execution of many engineering works. Until recently Mr. Maxwell occupied the position of the Assistant Engineer and Surveyor to the municipal authority at Leyton—a large district of over 100,000 inhabitants—the continual development of which constantly demands the carrying out of many important public works by the Council, involving the expenditure of very large sums of money. Mr. Maxwell has recently been appointed Borough Surveyor and Waterworks Engineer to the Tunbridge Wells Corporation, a position for which he is well suited. In his leisure he has found time to secure for himself the distinction of being the first to prepare a really comprehensive work, now to be found in nearly every municipal engineer's office throughout the country, upon the Construction of Town Refuse Destructors and the commercial value of same for purposes of Steam Raising. Mr. Maxwell is also the contributor of a technical article upon this subject to the Encyclopædia Britannica. He holds qualifications in Municipal Engineering and the allied subjects granted by the Association of Municipal and County Engineers, and he is also an Associate Member of the Institution of Civil Engineers.

THE steady increase in town population throughout this country during the Victorian Era has greatly affected many matters coming within the scope of municipal local government, and very prominent amongst these is the difficult problem of the disposal of town refuse.

However uninviting the subject may at first sight appear, it is one which demands the prompt and serious attention of those responsible for its satisfactory solution, affecting most vitally as it does the health and well-being of the public. At the present day the importance of the elements of sanitary science are sufficiently well recognised to render it unnecessary to dwell upon the need for the removal and efficient disposal of all refuse matter created by a population, and the experience of former years has well shown what are the baneful consequences to be expected from the neglect to perform this essential duty.

As the centralisation of population goes on from year to year, so the refuse disposal problem steadily increases in magnitude, not only from a public health point of view, but also from a financial standpoint. There is a commercial aspect of the subject now developing which, from its important bearing upon public funds, has of recent years called for the careful consideration of municipal authorities, municipal, electrical and mechanical engineers, manufacturers, and others.

Various means for the disposal of a town's refuse are adopted in different districts, according as best suits local circumstances. These methods it is found necessary to modify from time to time as the town develops and the population increases. The old methods—such, for example, as the tipping of refuse upon hollows or waste lands — become exhausted; the cartage or barging of the material to sites at considerable distances from the town boundaries becomes in-

creasingly expensive, besides being at best an insanitary mode of disposal.

Town refuse, it is found, possesses a calorific value varying from one-tenth to one-eighth that of coal; that is to say, it is worth as a fuel from 2*s.* to 4*s.* per ton, with coal at 20*s.* per ton; and the cheapest and most perfect method in the interest of the public health of dealing with this material is undoubtedly that of burning to an innocuous clinker in suitably designed high-temperature furnaces or "refuse destructors." These furnaces it is proposed to describe in the present article, and to give some criticisms of their proper design and installation, together with an investigation of actually attained results in the application of refuse-fuel to the purposes of steam raising, and of the extent to which the energy thus derived may be relied upon for the generation of electric power or for other commercial uses.

A population of say 50,000 will produce domestic household refuse at the rate of about 40 tons per day; and as it is absolutely essential that this material be satisfactorily and economically disposed of day by day, it is of paramount importance that the furnaces and plant employed be of the most perfect type for the primary purpose of burning the refuse, without thereby giving rise to the slightest nuisance or inconvenience to the neighbouring public. The secondary object of the plant must be to take the fullest possible advantage of the heat given out by the burning of the refuse for the generation of steam, in order that the cost of collecting and disposing of this material may be reduced by that means, and no available heat-energy allowed to run to waste.

Forty tons of refuse per day, or about 12,500 tons per annum, giving an evaporative efficiency at the rate of 1 lb. of water per lb. of refuse (a result very readily attained in practice), will develop a steam power of 1,400,000 i.h.p. hours annually, calculating upon a steam consumption for condensing engines of 20 lbs. of steam per i.h.p. per hour. Then, allowing 3 lbs. of coal as the fuel consumption per i.h.p. hour, this gives an equivalent of about 1,880 tons of coal per annum, showing the refuse in this case to be from one-seventh to one-sixth the value of coal for steam-raising purposes.

The importance of this phase of the question of the disposal of town refuse has very largely exercised the minds of public authorities, and considerable expense has been incurred in deputing representatives to visit the principal destructor stations throughout this country, in order to gain a knowledge of the best experience obtained with various types of plant. Continental towns, too, as well as many in the British Colonies, are well alive to the necessity of inquiring closely into this subject, and numerous special commissions have been formed for that purpose.

The value of refuse for fuel purposes naturally varies according to its composition. This is dependent very largely upon the locality, whether situated in a coal-producing area or not, also upon the habits and industries of the population. Varying proportions of cinders and unburned fuel are also to be observed in the refuse from different quarters of the same town, and it is found that householders who burn their own coal are generally less wasteful than a higher-class population at the mercy of servants. The proportion of vegetable refuse is also larger in summer, and cinders and ashes are less. The degree of moisture in the refuse is affected by the system of collection and the mode of storage upon the householders' premises pending its collection.

A hundred tons of London ash-bin refuse have been found to contain the following average proportions, which will serve to indicate the approximate constituents of the material we are now discussing in the present article:—

Composition of Refuse.	Tons per hundred.
Cinder and ashes	63·6
Coal and coke	·8
Fine dust	19·6
Straw, rags, waste paper, &c. ...	7·9
Bones	·5
Vegetable and animal refuse ...	4·7
Bottles, glass, crockery, &c. ...	1·9
Old iron, tins, and hardware ...	1·0
Total	100·0 tons

Of this material London produces about $1\frac{1}{4}$ million tons per annum, or about 4 to 5 cwt. per head per annum. In the North of England an average of about 8 cwt. per head per annum are collected; but the amount varies in different towns according to the mode of collection and other local details.

In designing a destructor station it is important to know the amount of refuse storage room that will probably be required on the "tipping platform" from which the furnaces are fed. This should be calculated from the weight of refuse to be dealt with per day—a cubic yard of ordinary house refuse weighing from 12 to 15 cwt.

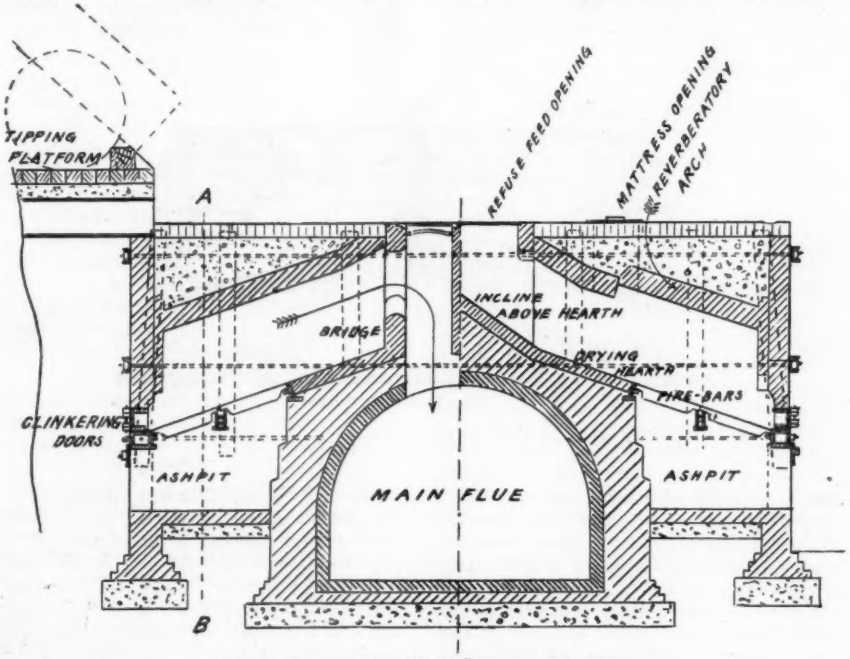


FIG. 1.—SECTION THROUGH "FRYER" REFUSE DESTRUCTOR.

Modern refuse-destructor plant, like most other useful mechanical contrivances, has had a checkered history. It has not sprung into existence suddenly, neither is it the sole product of one inventive mind. There have been many inventors, or perhaps in many cases more correctly *patentees*, and there have been very many failures to produce an efficient plant. In arriving at perfection in refuse-burning there is no sudden "eureka"; every point of good design is learnt only from actual experience, and from the practical test over prolonged periods.

Refuse furnaces of a sort, built mostly by dust contractors, were in use in London and the North of England over forty years ago, and it was about the year 1876 when the well-known "Fryer" Destructor was built at Manchester. This furnace, although very far from perfect, contained features which have been copied, with modifications, by several subsequent patentees. The "Beehive" Destructor of Richmond (Surrey) and the "Nelson" furnace erected at Nelson-in-Marsden are both familiar names to be remembered in the early history of destructors—the one for the

nuisances it created, and the other for its prohibitive cost of working.

Of modern furnaces the principal types now in use are those of Fryer (with improvements), Warner, Horsfall, Meldrum, and Beaman & Deas. We will notice a few of the main characteristics of each, after which some general conclusions or criticisms may be determined upon as to the design of a destructor station.

THE FRYER DESTRUCTOR.

This type of furnace, which is a comparatively low temperature destructor, was largely adopted some ten to fifteen years ago, and many important installations were built upon the Fryer principle throughout the country, of which many are in use at the present day, others have been either considerably modified or converted into other systems. In the more recent installations improvements have also been introduced adding to the efficiency of the furnace. The general arrangement of the Fryer Destructor was patented* by Mr. Alfred Fryer (of the well-known firm of Manlove, Alliott & Fryer) in 1876, and is shown in section in the accompanying figure (No. 1).

A destructor built upon this system consists of a block of cells or furnaces, usually arranged "back to back" in pairs. The top of the cells is formed level, so as to provide accommodation in the shape of a "tipping platform" for the storage of the refuse and for the feeding of the furnaces.

A cell measures internally about 9 ft. from front to back by 5 ft. in width, and is covered by a fire-brick arch about 3 ft. 6 ins. high above the grate. The floor of the furnace slopes, as will be seen from the figure, at an inclination of about 1 in 3, the rearmost portion of which next the fire-bridge, for a width of 4 ft., forms a firebrick hearth or dead plate. The front or remaining portion consists of fire-bars, having, therefore, a fire-grate area of 25 sq. ft., and a fire-brick or drying-hearth of about 20 sq. ft.

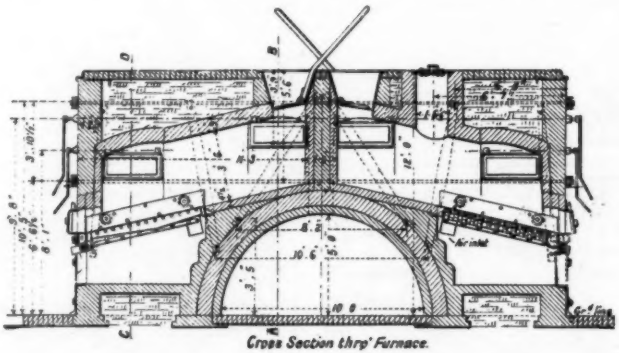


FIG. 2.—CROSS SECTION THROUGH "PERFECTUS" REFUSE DESTRUCTOR.

A wall at the highest end of the cell divides each furnace into halves; on one side the upper end of the slope is carried up with a steeper inclination (shown in the right-hand half of the figure) to a "feeding-hole" for the admission of refuse from the platform above, whilst on the other side is a passage forming an opening into the main flue for the escape of the products of combustion. When the cells are placed back to back with the feed-holes adjoining, only one opening is provided for each pair of cells. A large main-flue, acting also as a dust catcher, is placed under the drying-hearths.

Over the middle of one or more of the furnaces another opening fitted with a

* Patent No. 3125 (1876).

cover is provided and through which infected bedding, condemned meat, etc., may be inserted into the hottest part of the fire. Difficulty is experienced in passing bulky articles, such as mattresses, etc., through the space thus provided, and therefore presents the disadvantage of requiring the articles to be cut into small pieces.

Both the furnaces and flues are lined throughout with firebrick. The furnace doors are 5 ft. in width and are hinged at the top to open upwards with balance weights. In operating the furnaces, the refuse is moved forwards to the fire-grate area by raking from below with suitable tools through the fire door and pushing from the feed-hole above. The refuse-clinker is removed from the bars and raised through the burning cinders by the aid of long iron bars or clinkering tools, and raked out of the furnace at intervals of about two hours, or when considered sufficiently burned.

The refuse is either carted up an inclined roadway built between brick retaining-walls or raised by a lift to the tipping platform.

It will be observed that this furnace has the outlets for the products of combustion at the back of the cells near the refuse feed opening. This arrangement is a very undesirable one, inasmuch as whilst a charge is burning upon the fire-bars the following charge lies upon the dead hearth near the outlet flue, where it undergoes a stewing or partial decomposition, giving off offensive empyreumatic vapours, which pass away direct into the main flue to the chimney shaft without first being exposed to a sufficiently high temperature to render them perfectly innocuous, thus giving rise to nuisance. To endeavour to meet these difficulties, a secondary furnace, known as a "cremator," was in many cases introduced in the main flue leading to the chimney. Coke breeze was burned in this furnace, and a higher temperature thus maintained in order to cremate the fumes given off by the destructor cell; but this, in many cases, greatly increased the cost of dealing with the refuse and so led to its disuse.

The quantity of refuse dealt with by the Fryer furnace is not large, ordinarily varying from four to six tons per cell per 24 hours.

WARNER'S "PERFECTUS" DESTRUCTOR.

The Warner Patent "Perfectus"* Destructor (Fig. 2) is in general arrangement very similar to Fryer's, although there are many points of detail which differ materially from that type, such, for example, as in the provision of special charging hoppers, dampers in flue, modified position of outlets for escape of products of combustion, dust-catching arrangements, rocking fire-bars, and other improvements.

The house refuse, upon arriving at the top of the tipping platform, is shot into feeding hoppers, which consist of rectangular cast-iron boxes. At the lower part is a flap door turning on an axis and controlled by iron levers. When it is required to feed refuse into the cells the lever is thrown over, and the contents of the hopper fall immediately upon the fire-brick hearth beneath, the door being at once closed again. When the process of charging is to be performed, it is desirable that the door should be open as little as possible, in order to prevent the admission of cold air into the furnace at the back, as the inrush of cold air cools the gases or vapours evolved, lowers the temperature of the flues, etc., and carries paper and light refuse into the main flue.

The cells or furnaces are 5 ft. in width by 11 ft. from front to back, and have a fire-grate area of about 25 superficial ft., the rearmost portion of the cell consisting of an inclined firebrick hearth, upon which the refuse is first deposited and dries before being drawn forward to the fire-bars. The grate area is composed of patent rocking grate-bars, actuated by a lever for the removal of clinker, and upon these the combustion of the refuse takes place.

The furnace doors in front are of the sliding type, and are constructed of cast-iron, with hollow backs to allow of the attachment of baffled plates. Holes are made with the object of providing a small amount of air and a cooling effect.

A reverberatory firebrick arch is turned

* Patent No. 18,719 (1888).

over the grate and the drying-hearth, and is provided with openings for the exit of gases at the sides, as will be seen by examination of Fig. 2. These outlet openings are fitted with flap dampers, which are operated by horizontal spindles passing through the brickwork to the front of the furnaces, where they are fitted with levers. By this means each cell can be operated quite independently of the others, and each workman is thereby enabled to manage his own furnace. The dampers also tend to prevent dust escaping into the flues and chimney, and assist to keep the fires in a better condition. When the dampers are closed, cold air is prevented from passing under the reverberatory arch and into the flues.

The heated gases or products of combustion are sometimes taken by flues to a boiler-house for generating steam, although this furnace is not what is known as a high temperature destructor, and forced draught is not ordinarily applied. The patentees, however, have an improved arrangement for increasing the steam-raising capabilities of the destructor. In this, forced draught is introduced, and a tubular boiler is placed close up to the cells, instead of at a distance, as is done at Bath, for example, where an installation of this type was built in 1895.

The Warner destructor is also in operation at Hornsey, Bournemouth, Newcastle-on-Tyne, Winchester, Govan, Hyde, Royton, Southampton, and other towns.

At Royton the consumption of refuse is about 5 tons per cell per 24 hrs., about 8 tons being the maximum usually dealt with by this type of cell.

After an inspection of several types of destructors in use in England, the Warner "Perfectus" furnace was recommended by the City Surveyor of Sydney for the treatment of the refuse of that city.

THE HORSFALL DESTRUCTOR.

The Horsfall* refuse furnace is a high-temperature destructor, the original design of which was introduced very many years ago, but has from time to time been improved in important details, and in its modern form is of the general design shown in Fig. 3. The system, which has been largely adopted, may be seen in operation at Oldham, Leeds, Bradford, Edinburgh, Norwich, Berlin, Hamburg, and many other places. From the cross-section figure it will be observed that the same general feature of inclining cells back to back over a large main flue with a feeding opening vertically over, as seen in the Fryer type, is also retained in this system. An important new feature, however, is the altered position of the "outlet flue," which is placed as near the front of the furnace as possible and over the hottest part of the grate area. A blast flue for supplying forced draught is also introduced, which adds greatly to the temperature, consumption, and efficiency of the destructor.

The placing of the outlet flue at the front of the cell causes the gases distilled from the raw material or refuse to pass, on their way to the main flue, over the hottest part of the furnace, and thus to be brought into contact with the hot gases from the incandescent material on the fire-bars burning there under forced draught.

Steam jets are used to produce the forced draught. The steam so used is condensed by contact with the cold air which it injects, and the water thus produced is re-evaporated in contact with the furnace bars, keeping down their temperature and tending to increase their life.

A further function is attributed to the steam. In coming into contact with the incandescent fuel it is decomposed, the hydrogen being freed while the oxygen combines with the carbon in the fuel to form carbon monoxide. The decomposition of the water is effected by heat abstracted from the lower part of the fire, where it can be of comparatively small value for the cremation of the distillate. The "water-gas" (hydrogen and carbon monoxide) passes upwards to be burned by the excess air which it meets with over the fire, thus, it is claimed, serving to increase the temperature which would otherwise exist at the meeting of the products of combustion with the gases distilled from the raw material.

Where there are a number of cells,

* Patent No. 8999 (1887); No. 14,709 (1888); and No. 22,531 (1891).

charged and clinkered in rotation, they are arranged so as to deliver their gases into one main flue, and when the fire in one cell is green, the other cells are discharging hotter products, so that the temperature of the main flue is maintained at a high temperature, tending to render the escape of noxious vapours impossible. It is only after this mixing of the products of combustion that the gases reach the boilers.

In this destructor a blast pressure of 1 in. of water is maintained, and it is considered undesirable to exceed this amount. Effort is made to just maintain a balance of pressure in the cell during clinkering operations, so that no rush of cold air may take place through the flues while clinkering is going on.

The blast air is taken through cast-iron boxes fixed at the sides of the furnaces, as shown in the figure. The chief object of these is to prevent the adhesion of clinker to the side walls of the cells, the continual removal of which damages the brickwork of the cells.

Each cell burns from 8 tons of refuse per 24 hrs. at Oldham, to 10 tons at Bradford, the latter furnaces being of the latest type. The labour of stoking and clinkering the furnaces costs about 6*d*. per ton of refuse treated at Bradford, and 9*d*. per ton at Oldham.

This destructor, if properly constructed and well managed, may be safely erected in populous neighbourhoods without inconvenience to the public health or comfort.

The refuse destructor furnaces at Powderhall, Edinburgh, were originally of the "Fryer" type, with back outlet flues, and fitted with fume cremators. In an action by the proprietor of an adjoining estate, it was found that a nuisance from noxious vapours and dust was caused, and the Court remitted to Mr. Benjamin Hall Blyth, C.E., Edinburgh, and Dr. Odling, Professor of Chemistry in the University of Oxford, to visit the premises and report to the Court what alterations were necessary to render the working of the destructors innocuous; and subsequently the Horsfall Company were engaged to reconstruct the furnaces.

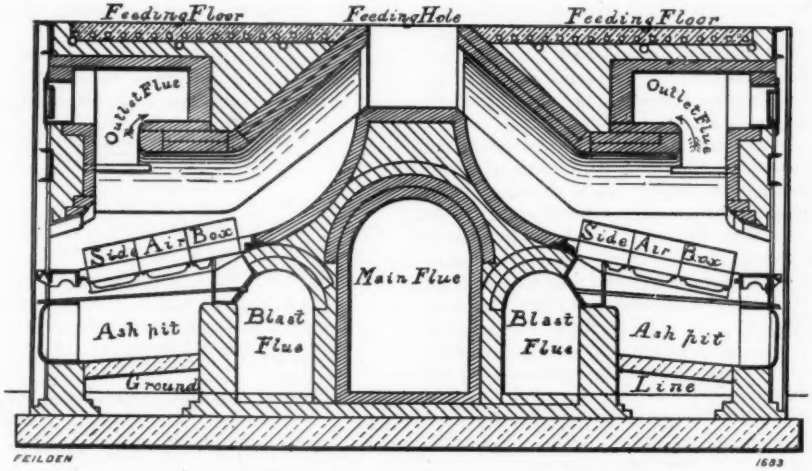


FIG. 3.—SECTION THROUGH HORSFALL'S REFUSE DESTRUCTOR.

The principal feature in the Edinburgh plant, as altered by Messrs. Horsfall, is the introduction of a dust-catcher consisting of a large circular brickwork structure about 16 ft. internal diameter and 12 ft. internal height, lined throughout with fire-

brick. In its centre is an inner cylindrical chamber 5 ft. 8 in. internal diameter, and about 12 ft. high, communicating with the surrounding annular space by arched openings at the top of the separating wall. The main flue from the destructor enters the annular chamber tangentially at the bottom, so that the flue gases pass round and upwards through the annular space before entering the central chamber above mentioned. From the bottom of this inner chamber the gases pass off to the boiler or bye-pass flue as may be required. In the floor of the outer spiral flue are several dust-traps provided, in which the dust carried outwards by centrifugal action from the whirling gases may be deposited. These traps or dust-pockets are provided with doors in the external wall of the chamber, through which the dust deposited can be easily removed.

Inspection holes at different levels are formed for examining the clearness of the atmosphere inside the chamber, and through which also the heat may be estimated. The apparatus is maintained at a temperature of from 1,500 degs. Fahr. to 1,800 degs. Fahr., and thus forms a large reservoir of heat, which is found useful in assisting to keep up steam in the boiler at an equable pressure over a long period.

The heat from this destructor is not utilised except to raise the small quantity of steam necessary for working the furnaces themselves and for producing the electric light for the premises.

The Bradford (Hammerton Street) destructors consist of twelve cells, which were erected to replace twelve cells of the "Fryer" type, and are arranged in two groups of six cells, in lines of three, placed back to back, and having one charging hole common to two cells. These furnaces are of the latest type constructed by the Horsfall Furnace Syndicate.

The gases from the main flues pass through two multitubular boilers, and the average rate of working is about 10 tons of refuse per cell per working day. The material is damp ashpit refuse, containing a large proportion of night soil and vegetable refuse from the market and shops. A cubic yard of the refuse weighs about 13½ cwts.

The temperature in the main flue is maintained at about 1,550 degs. Fahr., as measured by an electric pyrometer, and the refuse is thoroughly cremated without anything of the nature of a nuisance, only a faint trace of whitish smoke being discernible from the chimney, and even this becomes invisible at a very short distance away.

There are two multitubular boilers, each 11 ft. by 8 ft. diameter, and of 100 h.p., installed for use with the heat from the cells; but they are found insufficient to utilise the whole of the heat generated, and the temperature of the gases escaping to the chimney is over 1,000 deg. Fahr. The steam is usefully applied in—

(*a*) Lighting the works by electricity.
(*b*) Working mortar mills.
(*c*) Driving clinker crushing and screening machinery.
(*d*) Manufacturing manure out of fish refuse, and supplied to factory adjoining.
(*e*) Disinfecting bedding, etc.

The following is a true record of a week's work by the Bradford "Horsfall," destructor, according to tests carried out from October 18th to 23rd, 1897:—

Number of cells, 6.
Type of cells, Horsfall (back to back).
Duration of test, 141 hours.
Nature of fuel, unscreened midden and market refuse.
Number of men employed, including boiler attendant, 7.
Wages, 4*s.* 8*d.* per day.
Total quantity of refuse burned, 721,280 lbs. = 322 tons.
Total refuse burned per cell per 24 hours, 20,462 lbs. = 9·13 tons.
Total refuse burned per cell per hour, 852·6 lbs.
Total weight of water evaporated, 523,000 lbs.
Total weight of water evaporated per hour, 3,709 lbs. $= \frac{3709}{20} = 185$ i.h.p.
Total weight of water evaporated per cell per hour, 618 lbs.
Water evaporated per lb. of refuse burnt, ·725 lb.
Weight of clinker produced, 205,460 lbs. = 91·72 tons.
Weight of fine ash produced, 13,401 lbs. = 6 tons.
Total weight of residuals, 218,861 lbs. = 97·723 tons.
Percentage of residuals, 30·3.
Steam pressure maintained (by recorder), 60 lbs.
Temperature of feed water, 50 deg. Fahr.

Temperature of gases in main flue, 1,800 deg. Fahr.
Temperature of gases at chimney bottom, 900 deg. Fahr.
Average air pressure (water gauge), $\frac{3}{8}$ inch.
Total indicated horse-power per hour, at 20 lbs. steam per i.h.p. hour, 185·45.
Total indicated horse-power per cell continuously, 30·91.
Indicated horse-power hours per ton burnt, 81.

A test was also made to find the amount of steam used by the patent steam jets. The following are the results :—

Duration of test, 6 hours.
Total weight of water evaporated, 14,000 lbs.
Total weight of water evaporated per hour, 2,333·3 lbs.
Total weight of water evaporated per cell per hour, 388·8 lbs.

From the above tests it appears that the total weight of water evaporated per cell per hour is 618 lbs., and the water evaporated per cell per hour for use in the patent steam-jets is 388·8 lbs., which seems an astonishingly large proportion, being ·63 of the total.

The refuse burned per cell per hour is 852·6 lbs., and for this amount 388 lbs. of water is evaporated and used in the steam-jets; therefore, for one ton of refuse burned, 1,020 lbs. of water are required for the steam jet, that is,

$$\frac{\text{1,020 lbs. water evaporated}}{\text{20 lbs. per i.h.p. hour}} = 51 \text{ i.h.p.}$$

hours expended in steam-jets per ton of refuse burned.*

In the "Meldrum" blowers from 14 to 15 per cent. of the total steam, or about one-seventh, is expended. thus leaving a large net proportion for external work.

At Shoreditch the amount of electric energy absorbed in running the forced-air draught fans is four Board of Trade units per ton, that is (4 × 1·34) = 5·36 h.p. hours in fans per ton of refuse burned.

Forced-air draught is preferable to steam blast, and a direct-coupled electrically-driven fan is an economical arrangement from a mechanical point of view, and requires very little attention.

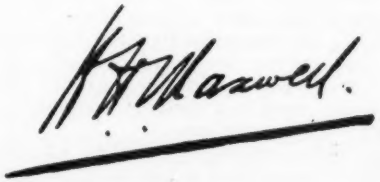
At Oldham is a 10-cell Horsfall Destructor, situated on a site adjoining the Corporation Electric Light Works, and to which undertaking it supplies steam power at the rate of about 120 i h.p. Steam is also used for heating food and driving the wheelwrights' shop in the Horse and Provender Department, and also for the manufacture of mortar and lime.

In a 24-hour trial at the Rhodes Bank Destructor, Oldham, conducted in May, 1898, the following data were ascertained :—

Refuse consumed per cell per 24 hours, 7·96 tons.
Proportion of cinder and ashes produced to refuse burned, 32·9 per cent.
Average boiler gauge pressure in lbs. per square inch, 128 lbs.
Average temperature of feed water, 57 deg. Fahr.
Water evaporated per lb. of refuse (from and at 212 deg. Fahr.), 1·06 lbs.
Temperature of flue gases *before* passing through economiser, 700 deg. Fahr.
Temperature of flue gases *after* passing through economiser, 555 deg. Fahr.
Approximate air consumption per lb. of refuse, 2·08 lbs.
Average draught in ashpit in inches of water, $1\frac{1}{8}$ inch.

(To be continued.)

* Since writing the above I am informed that subsequent to the date of the test referred to above the size of the steam-jet at the Hammerton Street Destructor Works has been reduced by one-half. It was found that similar results could be obtained by the expenditure of less than one-half the weight of steam, and the expenditure for this purpose now is approximately 190 lbs. per cell per hour.



The Central London Railway.

By W. N. TWELVETREES, M.I.Mech.E.

(*Continued from page 362.*)

❀ ❀ ❀

OUR attention must now be directed to the passenger lifts, which form so important a portion of the engineering equipment of the line. The preliminary specification issued by the engineers, when inviting tenders, contained very little detail, and gave prospective contractors the option of employing either hydraulic or electric power for actuating the lift machinery. Under these circumstances, it is a somewhat significant fact that an American firm, the Sprague Electric Company, of New York, should have been successful in securing the contract. Some brief account of the steps taken by Mr. Sprague, upon receipt of the specification, may well be regarded as a useful object-lesson. Although the information was thought to be "very meagre," Mr. Sprague determined upon a great effort to secure the work, and with the assistance of Mr. J. R. Furman, who erected the Glasgow Tunnel hydraulic lifts, and Mr. C. C. Stutz, provisional plans were prepared. These he brought to England in May, 1897, being accompanied by the two assistants named, and soon after his arrival, a tender was submitted for the entire plant. Finding it necessary to convince the authorities as to the superiority of electric over hydraulic power, and also to prove the desirability of his own scheme, Mr. Sprague submitted the following amongst other propositions:—

1. To buy current from the road at one penny per Board of Trade unit, and to work the lifts for three years at a cost not exceeding £1 per 1,000 trips;
2. To install a complete electrical equipment in one shaft, as against a direct or differential hydraulic plant, with electric pumps, in an adjacent shaft, and to operate the electric lift at one-half the cost of the hydraulic lift;
3. To enter into a contract conditional upon early delivery of a complete shaft equipment, to be worked to the entire satisfaction of the engineers to the Railway Company and of the Electric Traction Company.

It would appear that the last-named condition settled the matter, for shortly after the opening of the tenders, a contract was agreed upon, subject to the satisfactory performance of two test elevators. Immediately upon receiving a letter intimating these terms, Mr. Sprague returned to the United States to make preparations for putting the work in hand, leaving one of his assistants behind to collect further data. A complete plant was soon afterwards delivered in London, and erected by Mr. G. Rosenbusch. In the interim, so confident was the Sprague Company of success, that the remaining 47 equipments were at once commenced. The most important of the tests formulated by the engineers are stated below, as they show clearly how determined these gentlemen were to provide for the safety of the travelling public.

Test No. 1.—A running test of 16 hrs. with an average unbalanced load of 3,000 lbs., that is, 7,000 lbs. in the car, and 4,000 lbs. on the counterweight.

Test No. 2.—A test load with 12,000 lbs. unbalanced load, counterweight overloaded 5,000 lbs., and 17,000 lbs. of cast-iron was placed in the car.

Test No. 3.—A running test of the safety devices, during which the car was

loaded with 14,000 lbs., giving an un balanced load of 10,000 lbs.

Test No. 4.—The automatic device for stopping the car, in the event of cable-slackness, was tested by releasing the safeties, and noticing how much cable ran off the drum before the automatic stop motion came into action. In this test, three feet was the maximum length unwound from the time the safeties were sprung until the hoisting apparatus stopped.

Test No. 5.—It was assumed that the pilot motor would fail to operate, and the car was allowed to strike the limit stops at the top and the bottom of the journey.

Test No. 6.—The main circuit was broken whilst the car was ascending and descending, with no load and full load, and without the knowledge of the operator.

Test No. 7.—Trip tests at schedule time were made, and a series of 8 and 16-hour brake tests, with the motors running at full-rated load, were also made.

All the tests were satisfactorily undergone, and as to the requirement that an efficiency of 70 per cent. should be attained, it may be remarked that, in the contract test, an efficiency of from 70 to 75 per cent. was shown from the current at the brushes to the work on the ropes.

In the following table will be found the number and diameter of lift-shafts at each station, the number of elevator-cars, the height of lift, and some other interesting particulars :—

PARTICULARS OF LIFT SHAFTS, CARS, AND CABLES (Central London Railway).

Name of Station.	Lift Shafts.			Lift Cars.		Cables, all $\frac{7}{8}$" dia.		Counterweights per car.	
	No.	Dia. in feet.	Height of lift in feet.	No.	Area of each in sq. feet.	For counter-weight per car.	Lifting per car.	No.	Kind.
Shepherd's Bush	1	30	41	3	2 at 145 1 ,, 117	4	4	2	Simple.
Holland Park	1	30	51·5	3	2 ,, 145 1 ,, 117	4	4	2	,,
Notting Hill Gate ...	1	30	91·5	3	2 ,, 145 1 ,, 117	4	4	2	,,
Queen's Road	1	30	67	3	2 ,, 145 1 ,, 117	4	4	2	,,
Westbourne	1	30	41	3	2 ,, 145 1 ,, 117	4	4	2	,,
Marble Arch	2	23	74·5	4	,, 140	4	4	2	Compound.
Bond Street	1	30	61	3	2 ,, 145 1 ,, 117	4	4	2	Simple.
Oxford Circus	2	23	75	4	,, 140	4	4	2	Compound.
Tottenham Court Road ...	2	23	71	4	,, 140	4	4	2	,,
British Museum	2	23	69·75	4	,, 140	4	4	2	,,
Chancery Lane	2	23	76·5	4	,, 140	4	4	2	,,
Post Office ...	2	23	82	4	,, 140	4	4	2	,,
	1	18	82	1	,, 172	4	4	2	,,
Bank	5	20	50	5	,, 250	6	6	2	,,

Owing to the circular section of the lift shafts, the number of cars required, and the large loads contemplated, the lift cars are of various and very unusual shapes, as may be judged by reference to Figs. 57, 58, and 59. In the two-car, or 23-ft. shafts, the cars have a curious form, shown in plan and elevation by Fig. 57. The heavy construction is necessary owing to the dimensions of the car, and also to the requirement specifying that the safety clutch on one side might be released without springing the car framing. The cantilever supports for the corners and the diagonal bracing contribute further to the massive appearance of the structure. In Figs. 58 and 59 will be seen the over-

head arrangement and the disposition of the machinery at the bottom of a 30-ft. shaft. Fig. 60 shows the manner in which the cables are attached to the car frame. Steel T-guides are provided for the cars and counterweights, these guides being bolted to the cast-iron lining of the shaft. The car guides are milled to 1 in. thick, and special spring guide-shoes are necessary owing to the great length of the framing as compared with its height. Doors are provided both for regular use and as emergency exits; the inside lining of the cars is of oak, with an ornamental ceiling. A sketch diagram of the roping,

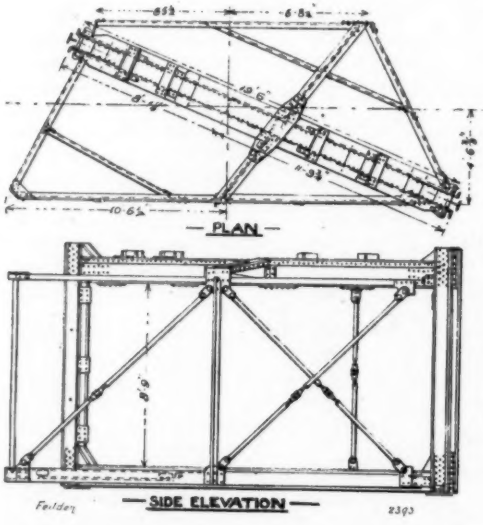


FIG. 57.—UNEQUAL SIDED CAR FRAMING, FOR ELECTRIC LIFTS IN TWO CAR SHAFTS.

or "cable layout," will be found in Fig. 61, where it may be seen that the lifting cables pass over the overhead sheaves and down to the under side of the winding drum. On the same drum, but wound in an opposite direction, are the drum counterweight cables, running under the vibrating sheaves and over another overhead sheave to the counterweight. In some cases the drum counterweight is simple, but where space is limited, it is compound, as drawn in Fig. 62. In the latter type, the cables pass beneath the counterweight sheaves and return to the overhead framing, thus reducing the distance traversed by one half. These multiplying weights consist of a frame supporting a grooved sheave having two pendent side rods, between which are placed as many cast-iron weights of about 280 lbs. each as may be necessary. An independent car counterweight is also indicated in Fig. 61. The cables consist of a main core of well-oiled hemp, round which six strands are laid, each strand being composed of 19 steel wires laid in two concentric circles around one central wire. All the wires except the centre one are of hard steel, carefully hardened and tempered; the cables ($\frac{7}{8}$ in. diameter) have an ultimate breaking strength of not less than 22 tons, and were guaranteed for twelve months after the opening of the line.

We now turn to the hoisting machinery, upon which the practical success of the whole lift installation depends. As may be seen by Figs. 63, 64, 65, it is simple and self-contained. The two side box-frames furnish bearings for the drum and other shafts, besides forming oil chambers in which the gears work. Adjoining each side frame, and directly connected to the worm-shaft, is a four-pole motor of the enclosed type. Each motor drives a shaft carrying two worms—one right hand and the other left hand—actuating two worm wheels, mounted on the drum shaft and "idler" shaft respectively. Bolted to the worm-wheels are two straight gear wheels, as shown in Figs. 63 and 64. This arrangement involves the running of the motors in opposite directions, both of them turning inward for hoisting and outward for lowering. Thus the thrusts and strains are so accurately balanced that friction, which is generally of so important a factor in gearing of this character, is

reduced to a minimum. Attention should also be given to the type of worm and worm-wheel adopted by the lift makers. Sketches in Fig. 66 represent an ordinary worm gear, and the "Hindley" worm and worm-wheel used in the Sprague hoist, and it may readily be seen that a much greater bearing surface is afforded by the latter. The worms and wheels are cut so carefully and engage so closely that they cannot be put in gear in the ordinary way, but the worm must be put into the wheel at an angle, and then turned into position. Considerable care has to be taken when erecting the hoisting machinery to see that the two pairs of straight gears and the four worm gears are in their exact relative positions, and that the opposing thrusts are accurately balanced. Incidental reference has already been made to the vibrating sheaves (Fig. 61), which are shown in detail by Figs. 63—65. It will be noticed that these sheaves are loosely mounted upon nuts travelling upon right and left hand travelling-screws cut in the idler shaft, the shaft being driven from the bevel gear on the second shaft of the hoist. The screw thread is of such pitch as to regulate the positions of the sheaves as may be necessary for the proper winding and unwinding of the ropes. As the sheaves are supported on a separate frame, this part of the apparatus can be placed at any distance within reasonable limits from the hoist proper, the length of the shaft transmitting power from the bevel gear being, of course, proportionately increased. Another feature in connection with the ropes is what is termed a "slack rope device," to be seen in Figs. 64 and 65. This consists of two small loose pulleys mounted on a shaft, held at its ends by a pair of levers secured to a shaft above, and counterbalanced so that the runner pulleys are always pressed against the ropes. In case the latter should become slackened through any cause, the frame will swing out and operate a switch, cutting off the current and throwing on the brakes which act upon the worm shafts. The mechanical features of

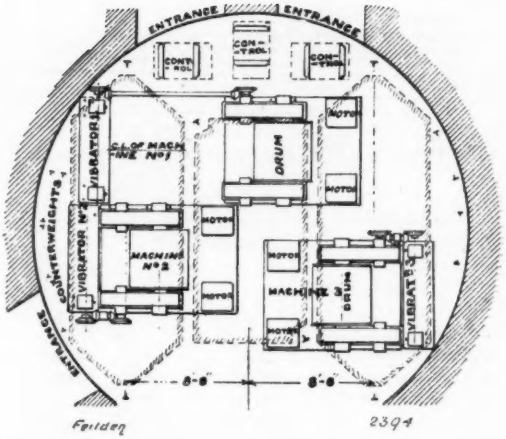


FIG. 58.—PLAN OF MACHINE ROOM AT BOTTOM OF 30-FT. LIFT SHAFT, SHOWING FORMS OF LIFT CARS IN DOTTED LINES.

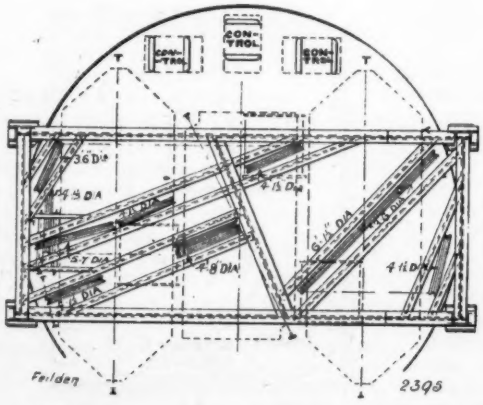


FIG. 59.—PLAN OF OVERHEAD ARRANGEMENT FOR LIFTS IN 30-FT. SHAFTS.

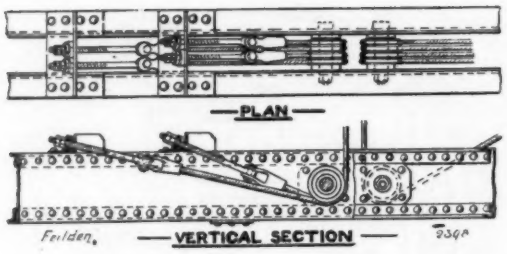


FIG. 60.—MODE OF SECURING CABLES TO LIFT CARS.

the brakes are clearly shown in Fig. 64, where it will be seen that friction wheels are attached to the shafts, and are partly encircled by blocks secured to curved levers, which are pressed together by powerful spiral springs. The free ends of the levers are connected to toggles, which in turn are connected with armature plungers under the influence of a solenoid magnet. When current is passing through the latter the toggles are drawn in, and the brakes are held off. If any interruption of the current should occur the armatures are immediately released, and the brakes are thrown on by the springs. Any serious mishap from the failure of a wire, or the interruption of current is therefore practically impossible. But if the current supply were interrupted during the descent of a heavily-loaded car, it might be that undue acceleration of speed would result in spite of the brakes. In such an event the safety gear would at once come into action, for the Sprague safety apparatus is governed by the speed of the car, and not by the failure or slackening of the ropes. As illustrated in Fig. 67, the clamps are fixed at the bottom and at each side of the car frame. They consist of hinged levers arranged to grip the guide rails between their short arms when the long arms are forced apart by wedges, drawn out by powerful springs. Under normal conditions the springs are held by catches so that the clamps remain open, but on the attainment of any excessive car speed the catches are released and the safeties are thrown on. This operation is due to the action of a centrifugal governor, to which is attached a small pulley directly actuated by one of the car ropes. As doubts are sometimes entertained, especially by persons of nervous temperament, as to the actual reliability of safety apparatus for passenger lifts, we think it well to state the tests to which the appliance in question was subjected by the makers, as a check upon the accuracy of the design. In addition, each apparatus has, of course, been carefully tested after erection by the engineers, both of the railway company and of the general contractors. A factory test was made by the Sprague Company, by springing one of the safety clamps upon a short section of guide rail. The whole was then put in a hydraulic press, where the rail was forced in one direction, and the clamp in the other. Repetitions of the test were conducted both with dry and with greasy rails, and the results showed that the clamp could not be moved with a less pressure than 24,000 lbs. This is equal to 48,000 lbs. for two pairs of clutches, and as the weight of a loaded car may be assumed not to exceed 40,000 lbs., there is an ample margin of safety. The

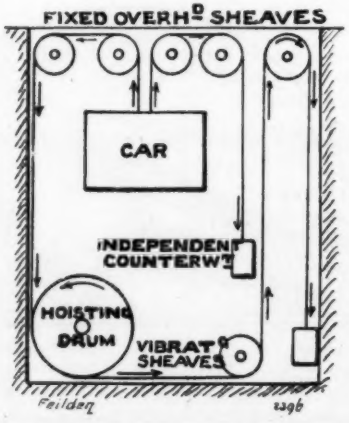


FIG. 61.—DIAGRAM SHOWING SYSTEM OF LIFT ROPING.

jaws of the clamps are faced with steel, diagonally grooved, the area per face being determined conformably with an allowance of 2,000 lbs. per sq. in. for safe compressive stress. A final test was conducted for the purpose of checking the correctness of this allowance. All the parts were first measured, and the safety apparatus was sprung twenty-four times in the ordinary manner. Upon measurements being again taken, with the heaviest pressure still on, no difference whatever could be detected. Oil buffers are placed on the car and counterweights, and although these are supposed to constitute an additional safeguard against accident, they would not of themselves do much to deaden the shock if a "runaway" car should strike the bottom with any great force.

For operating the car, a small circular switch-box is provided, containing six contact points, two contact arcs, and a lever, actuated by a loose handle fitting on a projecting shank. A spiral spring is connected to the inner lever, so that it may be returned to the "off" position if the operator releases the handle or removes it from the shank. Between the control switch (Fig. 68) and the controller in the machine chamber below connection is maintained by means of a flexible cable. This controller is really a resistance cut in or out of the motor circuits by a small "pilot" motor operated by the car switch. Very little current is required for working the controller, and if the main circuit current should fail, or the car should run into the top or bottom limit stops, the controller mechanism automatically returns to the "off" positions. The hoist motors themselves are provided with switches automatically operated by clutches, of which the acting part travels along a screw of such length that the stationary part is rotated when the car reaches the upper or lower limit of travel. If the cable between the car-switch and the controller were to fail, or if the attendant should suddenly become incapacitated, the electrician in charge of the machine-room could immediately disconnect the car-switch and operate the lift from an exactly similar switch fixed to the side of the main controller. Every one of the many safeguards mentioned above has been tested by the writer, in company with Mr. J. R. Furman, the engineer responsible for the lift installation, and it must be conceded that no precaution within the range of human ingenuity appears to have been omitted. The lift motors are shunt-wound, taking current in series with each other; thus the duty on each side of the hoist can be equalised for all speeds. When the car is loaded, as under ordinary conditions of work, current is only consumed during its ascent, and on the descending journey current is generated by the motors and, being returned to the line, a material reduction of current consumption is effected. Fig. 69 is a diagram showing the current taken from and returned to the line during an "up" and "down" trip. This diagram refers to the test elevator erected to which previous reference has been made.

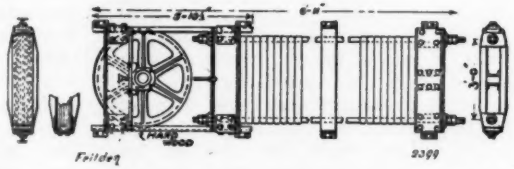


FIG. 62.—DETAILS OF MULTIPLYING COUNTERWEIGHT FOR LIFTS

With regard to the question of speed, the railway authorities must find it rather difficult to please everybody. Some adventurous persons would like the lifts to travel at a rate which would undoubtedly deter many timid passengers from making use

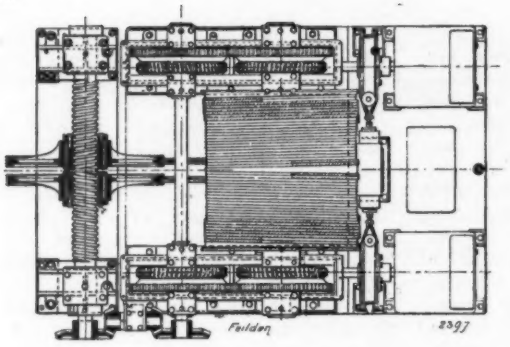


FIG. 63.—PLAN OF DUPLEX TANDEM WORM-GEAR ELECTRIC ELEVATOR.

of the line. Consequently the speed of 180 feet per minute has been adopted, instead of the somewhat higher velocity for which the lifts were originally arranged. As the essential point in connection with a railway such as the Central London is celerity in every possible direction, it would probably be an advantageous arrangement if one slowly-moving lift at each station were set apart for the use of timid passengers and those who are in no hurry, so that the remainder of the lifts might be run at the speed to which business men are accustomed. Such a plan as this ought to increase the popularity of the line, and it should tend to dispense with the annoying delays which sometimes occur in connection with the present service.

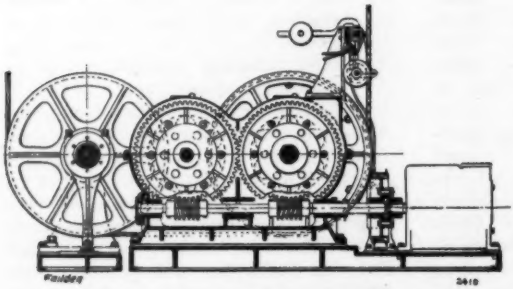


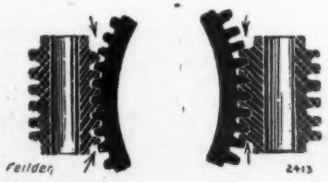
FIG. 64.—SECTIONAL SIDE ELEVATION OF DUPLEX TANDEM WORM-GEAR ELECTRIC ELEVATOR.

In a previous article the names of the passenger stations and the distances from one to another were fully stated; reference was also made by Mr. Hudleston to the assistance afforded to the locomotives by the tunnel gradients to employ the force of gravity in aid of acceleration and retardation, and although we believe that the proposal made was not at first approved by the other engineers concerned, yet it is gratifying to find that it was ultimately adopted. Fig. 70 shows the gradients throughout the whole line, but for the purpose of demonstrating the characteristics of electric traction, as exemplified on the Central London Railway, we will take that section of the line between Oxford Circus and Tottenham Court Road stations. As indicated at the right-hand side of Fig. 71, the gradients starting from Oxford Circus are as follows:—160 ft., level; 295 ft., 1 in 30 down; 925 ft., 1 in 622 down; 525 ft., 1 in 60 up; 160 ft., level. In the left-hand curve the speed of the train is given in feet per second, and in the right-hand curve of "space and time" the ordinates represent feet, and the abscissæ represent seconds.

Other lines on the left-hand of the diagram show the draw-bar pull, the track and gear friction, and the air resistance.

At the starting of a train the motors give a draw-bar pull of 9,600 lbs., which continues for 18 secs., as indicated on the top line of the diagram. The train has then traversed the 160 feet of level track, having attained a speed of 17 ft. per second. On entering the down grade of 1 in 30 a considerable acceleration is obtained concurrently with an important reduction of draw-bar pull, which suddenly

drops from 9,600 lbs. to less than 3,200 lbs., whilst the train speed continues to increase, as shown by the curves. The incline is traversed in 10 secs., the speed being then 33 ft. per second, and the draw-bar pull about 2,600 lbs. Of this little more than 880 lbs. is available for acceleration, owing to absorption by friction and air resistance. Throughout the gentle down gradient, 925 in length, the train still gathers speed, and 58 secs. after starting it is running at the maximum rate of 36 ft. per second, equal to 24·5 miles an hour. At the commencement of the up gradient, current is cut off, draw-bar pull ceases, and the train comes to rest in 34 secs. at the station level. Turning now to the right-hand side of the diagram, acceleration and retardation may be followed, and the influence due to the motors, to gravity, and to the brakes may be readily traced. Commencing at the left hand, the total acceleration due to draw-bar pull, minus friction and air resistance, is represented by the line marked "3 & 1." Acceleration is constant for 18 secs., being 0·895 ft. per second per second. On the first down grade the draw-bar pull is reduced, but acceleration is still attributable to the motors, as well as to the force of gravity whose effect is indicated by the height of the dotted line "2," above the zero line, and the total acceleration of 1·271 ft. per second per second continues until the nearly level length of 925 ft. is reached. Then the acceleration due to gravity drops to 0·06 ft. per second per second, the total acceleration being 0·15 ft. per second per second. Speed continues to increase until the up-gradient is encountered, when the retardation, denoted



ORDINARY WORM-WHEEL. HINDLEY WORM-WHEEL.

FIG. 66.—COMPARISON OF ORDINARY WORM-WHEEL WITH THE PATTERN EMPLOYED.

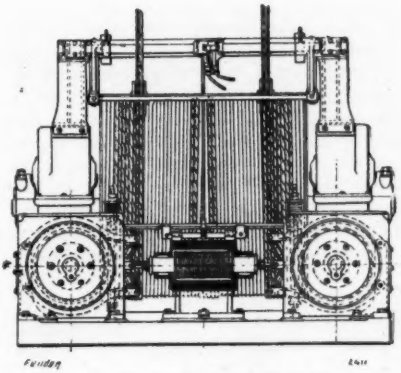


FIG. 65.—END ELEVATION OF DUPLEX TANDEM WORM-GEAR ELECTRIC ELEVATOR.

below the zero line as "negative acceleration," is 0·705 ft. per second per second, and its effect is evidenced in the "speed and time" curve. By reference to Fig. 72, it will be seen that the brakes are only applied as the train enters the station, the speed then being about 17 miles an hour. Some interesting data with regard to horse-power are contained in Fig. 72. In curve "1," starting at the left-hand bottom corner, we find the power required for overcoming air resistance, the maximum being about 12·5 h.p. Curve "2" shows the power accounted for by track and gear friction at varying rates of speed. Power expended in acceleration by means of the draw-bar is represented by curve "3." Its maximum is attained during the twentieth second; a drop is experienced as the down gradient is entered; a rise occurs with increase of speed until the thirtieth second; another fall takes place as the electric power is suddenly decreased; and finally there is a gradual rise as speed increases until the current is cut off at the fifty-eighth second. From the last curve we find the maximum power to be rather more than 300 h.p., and the average during the expenditure of energy is about 157 h.p.

The writer has now reviewed, though inadequately, the chief mechanical and electrical features of a great undertaking which, in spite of possible faults here and there, reflects the utmost credit upon

all who have been concerned in its execution.

Ventilation of the stations and running tunnels of the system is effected in a manner similar to that adopted on the City and South London Railway, but, so far, with better results than have been achieved on the latter system. As the "up" and "down" tunnels are separated for the greater part of their respective lengths, air is propelled before, and follows

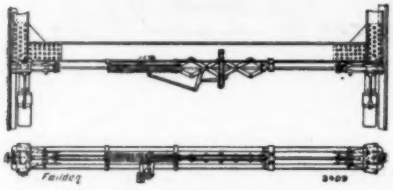


FIG. 67.—SAFETY APPARATUS ON LIFT CARS.

after, every advancing train, and the theory is, that foul air ought to be expelled, whilst fresh air is drawn in at each station. No doubt this is the case to a considerable extent, although it seems probable that currents of air movement between one tunnel and the other. We believe no investigation has hitherto been made as to the chemical composition of the atmosphere at different parts of the railway, but it is certainly desirable that periodical tests should be undertaken. The data thereby obtained would be of the greatest interest to scientific men, and they might be pleasing to the travelling public. Although the inter-communications existing between the tunnels tend to interfere with ventilation in some degree, they afford safeguards in more than one way, and it is probable that through them supplies of fresh air may gain access, in time of need, from one tunnel to a temporarily disabled train in the other. One or two cases have already occurred where trains have been detained on the line. On each occasion it was found that the atmosphere became "exceedingly oppressive," and, presumably, the passengers were proportionately apprehensive of various undefined dangers. Under such circumstances, a state of "oppression," which would pass almost, or entirely, unnoticed in a stuffy dwelling-room, or in the streets during a sultry summer day, might seem unbearable to persons helplessly imprisoned 70 feet below the light of day. If the carriage doors and windows remained closely shut on the occasions in question, there would naturally be a perceptible increase of temperature in a crowded train, and this alone might cause discomfort, although there could hardly be any risk of asphyxiation, even to passengers electing to remain in the carriages. From our illustrations,

FIG. 68.—DIAGRAM OF CONTROL SWITCH ON LIFT CAR.

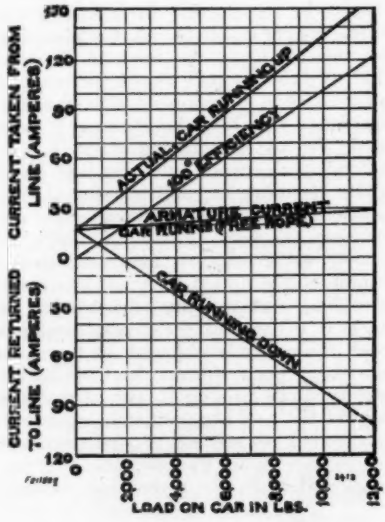


FIG. 69.—DIAGRAM SHOWING RELATION BETWEEN LIFT CAR LOAD AND ELECTRIC CURRENT.
(500-volt circuit, with two motors in series.)

it will at once be seen that, although the carriages fit the tunnel closely, egress is always possible from the end coach of the train.

Since the publication of our original reference to the Bank subways, a report has been issued by the engineer to the City

Corporation as to the number of persons entering these passages. On Wednesday, August 15th, 1900, it was found that 46,928 persons entered the various approaches during the 19 hrs. 50 mins. between 5 a.m. and 12.50 a.m. on the morning following. Deducting 20,424 passengers booked at the Bank Station (C. L. R.) and 6,900 booked at the City Station (W. & C. R.), we find that the number of persons using the subways, irrespective of those going to or coming from the railway stations, was about 19,600. As the total number of pedestrians crossing the open space in front of the Mansion House during the same period of time is estimated at about 190,000 daily, it seems at first sight that comparatively little use is made of the subway as a means of avoiding danger. But we must remember that a large proportion of the railway passengers would have to cross the surface to the omnibus stopping-places if no railway existed, and that an equal percentage of the passengers now arriving by both lines would be under the same necessity. The actual extent to which the new means of communication is appreciated by the public is therefore much greater than would appear from the figures at first quoted.

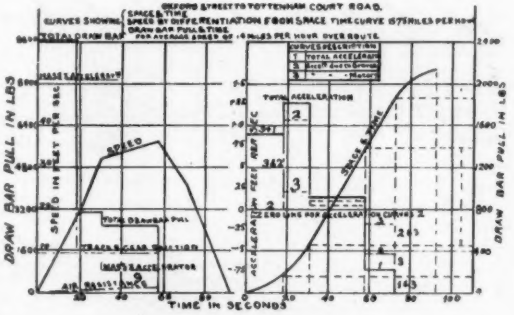


FIG. 71.—DIAGRAM DEMONSTRATING THE CHARACTERISTICS OF ELECTRIC TRACTION ON CENTRAL LONDON RAILWAY.

So far as the line itself is concerned, the most objectionable feature, in the view of many people, is said to be its extreme popularity, resulting in an embarrassing superabundance of passengers. Along a part of its course there are objections from some of the residents on the score of noise and vibration. Similar conditions are apt to extend to other forms of traffic. The omnibus, the tramcar, the railway van, and the butcher's cart are all more or less given to the evil habit of producing noise and vibration. There are also many other annoying things in the world, which the most peace-loving amongst us will never succeed in wholly suppressing. London wants, and must have, more electric railways, even if they do make a little noise; but of course there should be none which is clearly avoidable. The abolition of heavy electric locomotives, and the application of motors to each or, perhaps, every second car, would undoubtedly lessen the vibration of which complaints are now made. If our readers will take the trouble to observe the effects produced as a train comes to rest at any station of the Central London Railway, they will not fail to realise that the noise and vibration caused by the locomotive is very much greater than that due to the coaches. It will then become evident that distribution of weight must minimise, even if it cannot entirely obviate, undesirable conditions. Attention to this point is all the more necessary because there is already some talk of opposition to the numerous schemes that will shortly be brought before Parliament for the construction of electric railways in various parts of the Metropolis. With regard to such projected lines, we think it advisable that a special "Transit Commission" should be constituted, having power to consider the details of the schemes and also to decide how far each one is to be recommended as a unit in one comprehensive system of inter-communication for the whole province of London. By the term inter-communication it is not intended to imply that junctions should be effected between the running tunnels; but there should certainly be facilities at

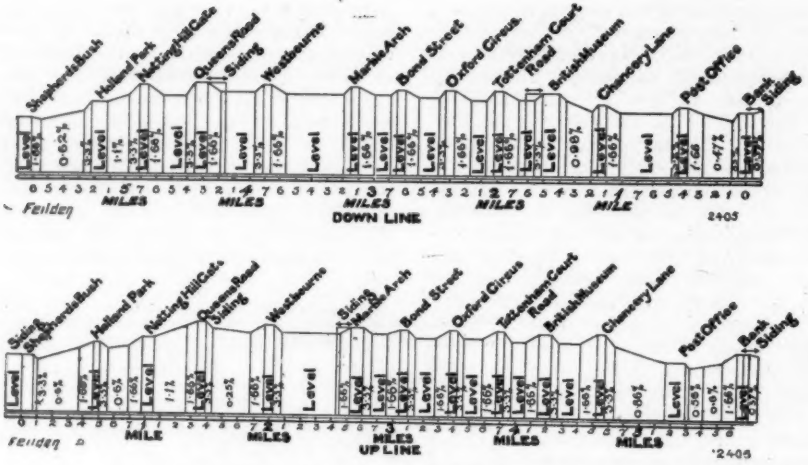


FIG. 70.—PROFILES OF "UP" AND "DOWN" LINES OF CENTRAL LONDON RAILWAY.

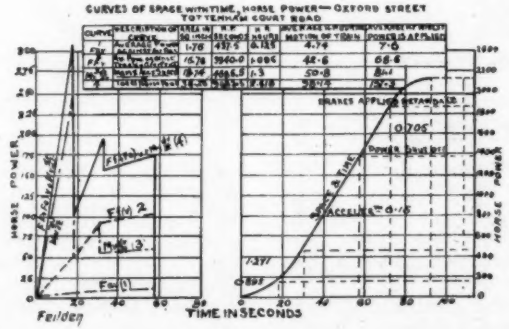


FIG. 72.—DIAGRAM DEMONSTRATING CHARACTERISTICS OF ELECTRIC TRACTION ON CENTRAL LONDON RAILWAY.

various points, enabling passengers to change from one line to another. Although not the pioneer line, the Central London Railway is at any rate the most perfect example of its class, and its successful inauguration has served as an admirable object-lesson, which it is to be hoped will not be lost upon those imperial and local authorities who have the power of life and death over similar enterprises intended for the improvement of metropolitan communications.

W. H. Wheeler

MACHINERY, APPLIANCES AND PROCESSES.

"Every part and side of our life, from the cradle to the grave, has been touched and tended by the inventor and manufacturer. His works are as numberless as the sands of the sea, but the onward rush of Science and the Arts opens up new fields of discovery and enterprise as each day dawns. Let us choose here and there among thousands, and in choosing take the best as far as in us lies."

A NEW BEVEL GEAR CUTTING MACHINE.

THE general idea which has largely prevailed amongst engineers that bevel gearing is a very inefficient method of transmitting motion has mainly resulted from the fact that until lately the gears in use have mostly been cast instead of being machined from the solid. Theoretically, bevel gearing is as efficient if not more so than spur gearing, and practically it can be made so if care is taken in forming the teeth correctly. The immense impetus which the machine tool industry has received of late years has caused builders and designers alike to inquire carefully into the best way of making the teeth in various forms of gearing. As is well known, there is hardly a machine tool that does not contain some bevel gear in its construction, and since modern practice has failed to improve upon this method of driving, it has sought to make it as perfect as possible. It is difficult to realise that until the last few years cut gears were the exception rather than the rule, and even now more cast gears are in use than is at all desirable. Whilst it has now become quite an easy and straightforward matter to cut spur gears, the same remark hardly applies to bevel gears, which is due to the fact that the machines have either been complicated or expensive, or would not entirely complete the operation, but have left something to be done by hand. Since, however, there is always a supply when there is a demand, various machines have from time to time been put upon the market. They may be roughly divided into two classes, viz :— (1) those that plane the tooth, and (2) those that remove the metal by means of a revolving cutter. The machine that it is now proposed to describe belongs to the latter class, and unlike some of its predecessors of this type, it removes all the metal necessary to leave a perfect tooth, and without any after treatment in the vice.

The "Rice" Bevel Gear Cutting Machine is an American invention, and was originally designed to cut the bevel gears used on the Columbia bicycle. This is not the first occasion that the cycle and motor car industry has been instrumental in raising the standard of machine tool construction, and especially in relation to gears and bearings. The machine works on the template principle, that is it does not generate its own curves, but relies on a template whose curves it reproduces. In fact, it is a profiling machine. The template, which is in the form of a bevel wheel, is, of course, very accurately cut, and is made five times the size of the wheel to be cut, so that any error which may exist in the master gear is reduced to one-fifth its magnitude in the

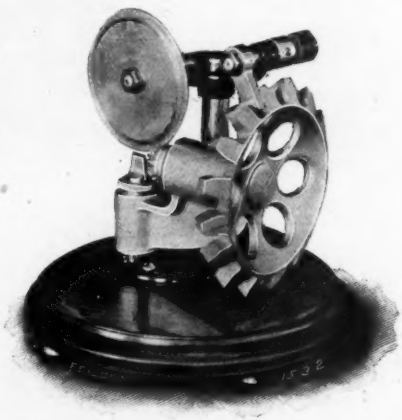


FIG. 1.—MODEL SHOWING THE PRINCIPLE UPON WHICH THE MACHINE IS CONSTRUCTED.

manufactured gear. For instance, supposing a tooth of the master gear is one-half of a thousandth part of a foot too thick at some point, the corresponding tooth of the work is only one ten-thousandth too thick. Also the indexing or placing of the teeth at equal distances apart is controlled by the master gear. Coming now to a description of the machine, this will be more readily understood by reference to Fig. 1, which shows a model which has been made for the purpose. The large master gear will be seen at the right, mounted upon the outer end of a horizontal axis, and the gear to be made (already cut) is upon the inner end of the same axis. This axis is mounted upon a swinging arm, which may oscillate abou' a vertical axis.

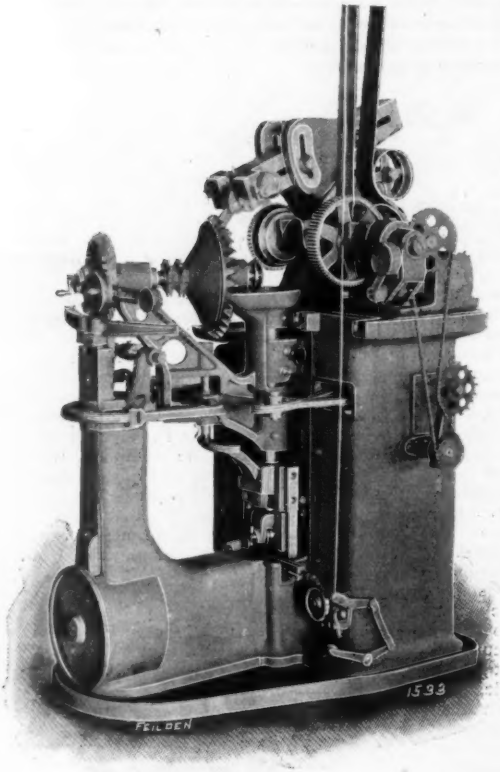


FIG. 2.—GENERAL VIEW OF "RICE" BEVEL GEAR CUTTING MACHINE.

The cutter, represented by a large disc, is mounted upon a second, but fixed, horizontal axis, and is shown engaging with the teeth. A fixed stop, called the guide-plate, enters a space between the teeth of the master gear. The contact face of the guide-plate is in a true plane with the working face of the cutter, and this plane contains the apex of the pitch-cone and the axis of the vertical shaft. It will at once be seen that if the tooth of the master gear be held in contact with the guide-plate, and if, while in such contact, the swinging arm be swung away from the observer, both the master gear and the gear to be cut will have a double motion, consisting of the swinging motion of the arm and a turning motion about their own axis, and during the motion the cutter will obviously reproduce on the blank, and upon a reduced scale, the curves of the master gear tooth. Fig. 2 gives a general view of the machine, and from the description given of the model the various parts already referred to will be readily recognised. Referring to Fig. 3, *G* is the guide-plate, *D* the master gear, and *E* the blank being cut, both *D* and *E* being mounted on a spindle *B*; *M*, the milling disc with cutters *H*. The swinging arm which carries the spindle *B* is mounted on a vertical shaft *A*. Reference to Fig. 4 will show a pitch-chain *O* for driving a sprocket-wheel *P* on the side of the main frame. This sprocket-wheel drives a shaft *Q* (Fig. 3) which, through worm and worm-wheel *R*, drives the vertical shaft *S*. Through the bevel wheels below, shaft *S* in turn drives shaft *V*, on which is mounted a cam which elevates the swinging frame through the vertical shaft *A*. At the opposite end of the shaft *V* are two other cams, one for operating the indexing mechanism and the other for operating an arm attached to the framing belonging to the swinging frame already referred to. At the top of the vertical shaft *S* are two cams, which operate the triangular levers *XX* of Fig. 5. Each of these levers connects with a link at its outer end, and these links have jaws which engage with a block which is located on the swinging frame. The action

of these connections is to accomplish the swinging motion for the purpose of keeping the guide-plate against the master tooth, as referred to in the description of the model. The connections upon one side accomplish the motions for one side of the teeth, and those upon the other for the opposite side. An index-plate will be seen at the left (Fig. 2). The purpose of this is merely to insure the entering of the guide-plate in the master gear as the swinging arm is raised to position for each cut. Once this is accomplished the index-plate is disengaged, and the master gear

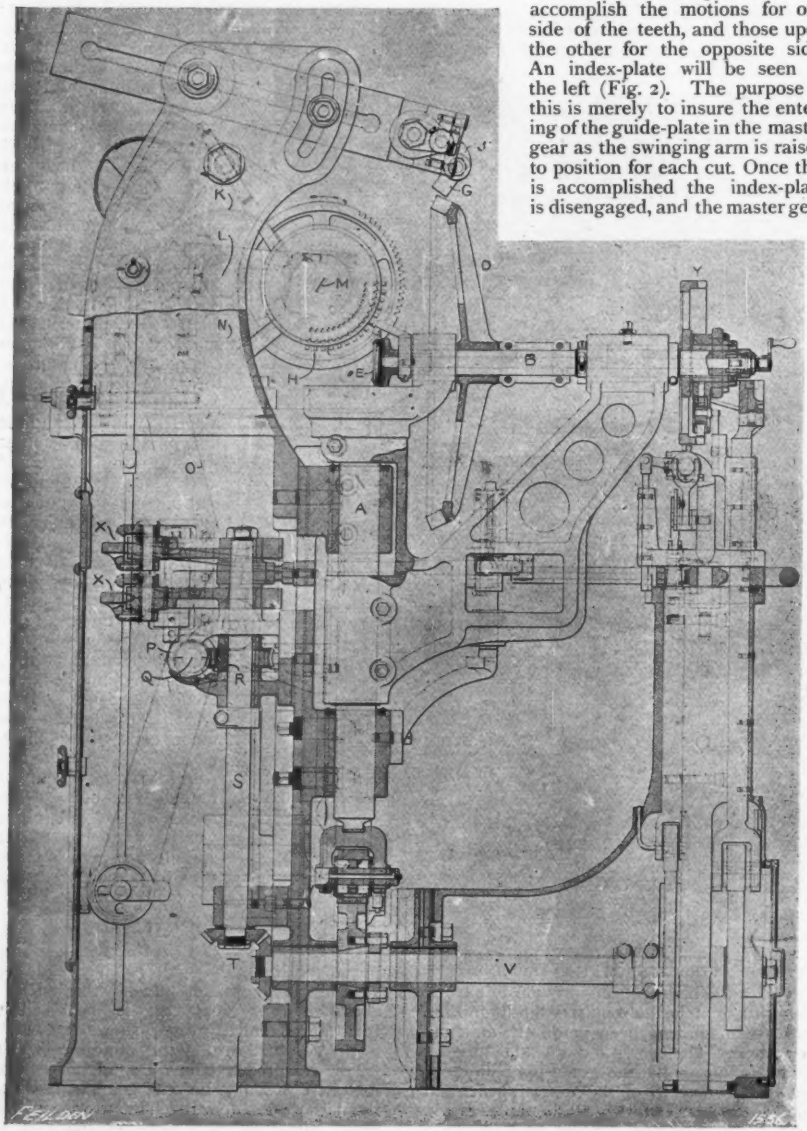


FIG. 3.—"RICE BEVEL-GEAR CUTTING MACHINE, TRANSVERSE SECTION

has full sway throughout all cutting operations—that is to say, the master gear governs the tooth spacing, the tooth thickness, and the tooth form.

Having now referred to the main working parts, it may be interesting to briefly describe

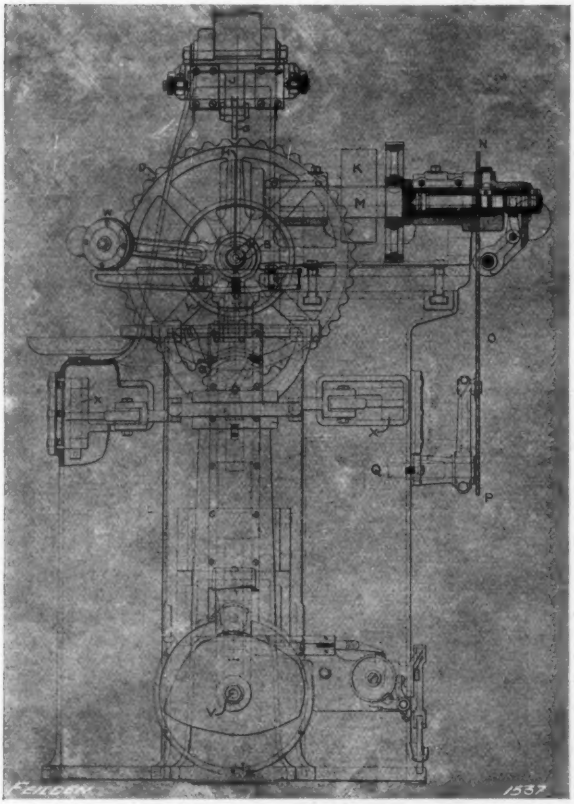


FIG. 4.—"RICE" BEVEL GEAR CUTTING MACHINE, FRONT ELEVATION.

THE OPERATION OF THE MACHINE.

The work having been previously gashed to approximately the required depth, and the adjustments having been made, the machine is started. The work and the master gear at once rise rapidly, the guide-plate entering between two teeth of the master gear, and the cutter between two teeth of the work. The upward motion is then retarded to a cutting feed, and the cut is made to the required depth. During this vertical cut the horizontal spindle has revolved so as to bring the base of a tooth of the master in contact with the guide-plate. This contact is thereafter maintained and controlled by the weight *W* (Fig. 4). The work and the master then swing about the vertical spindle, the controlling weight all the time keeping the master tooth in line with the guide-plate. Thus the entire surface of a tooth of the pattern is wiped over the guide-plate. The result is the cutting of one face of one tooth, a single sweeping cut having produced a smooth copy of a face of the pattern. As soon as this operation is completed the pressure on the guide-plate is relieved, the parts swing back and move downwards, and the horizontal spindle rotates so as to bring master and work into position for cutting one face of the next tooth. When one face of each tooth has been cut, the machine stops automatically. The cutters are moved horizontally, under the control of the micrometer screws, a distance equal to their thickness. So, also, the guide-plate is moved horizontally through a distance equal to its thickness. As a result the new working faces are in the fundamental plane. The swing of the controlling weight and that of the spindle are reversed, and the remaining faces of the teeth are cut.

THE CUTTERS.

It is of the first importance that the cutters be made as accurate as possible, and in the "Rice" machines very great care is exercised in their manufacture. Fig. 6 shows the cutter complete with part of the spindle on which it is mounted. They are of large diameter (8 ins. for bicycle gears), as since the cutter does not travel lengthwise of the tooth being cut, the resulting space is, of course, cut slightly deeper at its centre than

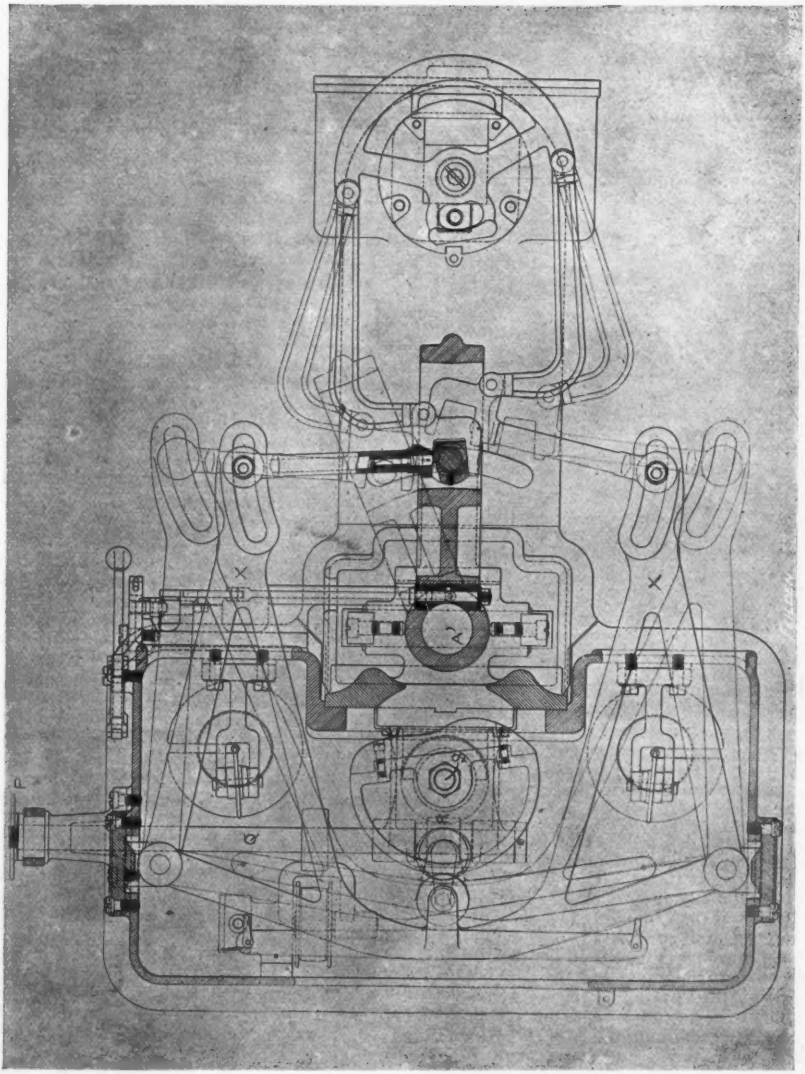


FIG. 5.—"RICE" BEVEL GEAR CUTTING MACHINE, SECTIONAL PLAN

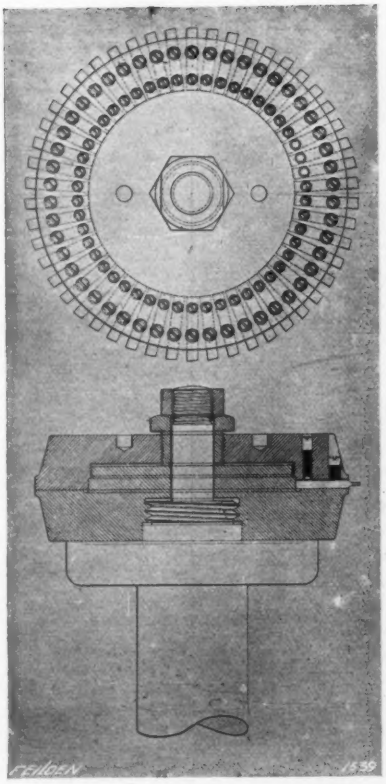


FIG. 6.—MILLING CUTTER IN ELEVATION AND SECTIONAL PLAN, AS USED ON "RICE" BEVEL GEAR CUTTING MACHINE.

at its ends; hence, in order to reduce this to an unobjectionable amount, the cutter is made large, as stated. The cutter head consists of suitably shaped discs mounted upon a hardened steel spindle. The discs are also hardened and ground, and the cutters, the shape of which is seen from the illustrations, placed between them and held by binding-screws. By having a large number of cutters to each cutter head the actual work done by each cutting edge is extremely small, and from actual tests made it was found that for each ten-hours day each tooth actually cuts metal during 31 seconds only, which would require 116 ten-hour days to make the actual cutting time equal one hour. Considering this short service, and the fact that heating is impossible, and thorough lubrication is insured, it is not surprising that the cutters are long-lived. The makers have adopted a number of special machines for the manufacture and upkeep of the cutters, and they have been found to well repay the necessary outlay.

The "Rice" machine has been well thought out, and should find a ready market wherever bevel gears are being made.

SIGNALLING WITHOUT CONTACT.

BOULT'S SYSTEM OF RAILWAY SIGNALLING.

IN our April issue last year we described the Brierley system of fog-signalling by the impact of a pendent lever on the engine against a movable stop or "rocker" on the road. As a contrast we give here a short description of another system which, according to the inventor, is so devised as to convey to the engine, in both foggy and clear weather, all the information that is at present conveyed by the roadside signals in clear weather only, and which is unique in that it requires no contact whatever between anything on the road and anything on the engine, while, besides, it possesses the advantage of being applicable not only to the stopping of trains, but also to starting them. It appears to be, in fact, the only system completed in every detail so as to provide on the engine a really practicable signal for stopping, starting, and selecting the desired road among any number of tracks. The system has undergone a very severe test on a Great Northern express engine at a speed of fully 70 miles an hour, and we understand that it is highly thought of by the Board of Trade and some of the most distinguished railway experts.

There can be no doubt that a reliable system of signalling in foggy weather, when frequently the line ahead and the road signals are quite invisible, is one of the desiderata of railway engineering, since it is just in such weather, of course, that the danger of collision is greatest. The method of fog-signalling employed up to the present is semi-barbarous, and instead of being exceptionally clear, as it ought to be, in consideration of the increased danger, is infinitely less reliable than that used on bright days. In daylight, during clear weather, the arm of the semaphore remains in a horizontal position, *i.e.* indicates "danger," until it is pulled down to a drooping position by the signalman to indicate that the road

is clear. The whole system of wires, chains, rods, sheaves and levers operating it is so arranged that if any breakage should occur the arm remains in or automatically reverts to the "danger" position. Moreover, in order to give the signal that the line is clear the arm of the semaphore not only has to be pulled down but must be held down until the train has passed. In other words, the "danger" position is the normal one, and the "line clear" position can only be given when the signalman is present to operate the pivoted arm. The moment the train has passed, he lets the arm rise again to "block the line" until it is necessary to give a new signal. When the track divides, each branch is supplied with its own semaphore, so that the driver can see at once which of the lines is 'made," or open, for only one of the lines can be "made" at the time, and only the corresponding semaphore can be pulled down. At night the position of the arm is indicated by means of coloured lights, red for "on," green for "off." In clear weather, therefore, both by day and night, *positive* "line clear" signals are given, without which no engine is allowed to proceed. But what happens in foggy weather, when no semaphore position can be seen in daytime, and when no light can be recognised at night, *i.e.* when as above said, the chances of accident are immensely increased, since the driver is often unable to see even a yard ahead, and is more than ever dependent upon signals? Incredible as it may appear to the uninitiated, in such weather all positive signalling is shifted from "line clear" to "danger;" *i.e.* the *normal* situation is such that the driver will go ahead, "assuming" the line to be clear, unless his engine passing over a detonator causes it to explode. This explosion is the only warning to him that the line is "blocked." In theory, it is true, he is expected to rely, as he does under ordinary circumstances, upon the semaphore signals or hand signals given by a "fogger"; while the explosion of the detonators is to be only an "additional" warning, but this theory is merely a pleasant fiction, for it cannot endow the eyesight of the driver with the gift of piercing the fog. This has been proved by very costly lessons of experience, and the great number of collisions during the winter of 1899—1900 has shown only too plainly that the driver entirely depends in foggy weather upon the detonators, which he treats, and must treat, not as "additional" signals, but as the only signals to guide him. In other words, unless he is warned by the explosions, he assumes that the road is clear, an unavoidable but most dangerous assumption, for the detonators may fail to act at the most important moment.

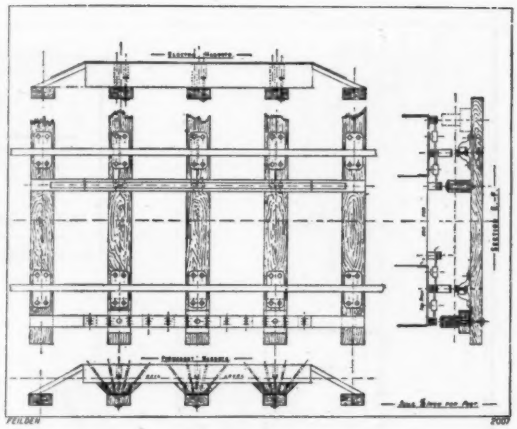


FIG. 1.—ROAD MAGNETS: BOULT'S SYSTEM OF RAILWAY SIGNALLING.

One of the special objects of Boult's system, described in the following pages, is to remedy this important defect in fog-signalling by making a *positive* "line clear" signal necessary not only in clear, but also in foggy weather, ere the engine is allowed to proceed.

In brief outline, his system consists in placing on the road magnets so arranged as to establish a long magnetic field of transverse polarity, and carrying on the engine through this field an iron armature, not itself to be moved by attraction to the magnets, but containing in a dividing gap or space therein a small pivoted needle on which magnetism collected by the armature is condensed or focussed so as to strongly act upon it and throw it over to one side. The polarity of the field from the road magnets is arranged to be from right to left, or left to right, as required; and, as the direction in which the needle in the moving armature is thrown over depends upon the polarity of the magnetism collected by the armature, it is evident that the combination forms a simple means of determining the movement of the needle. The needle when

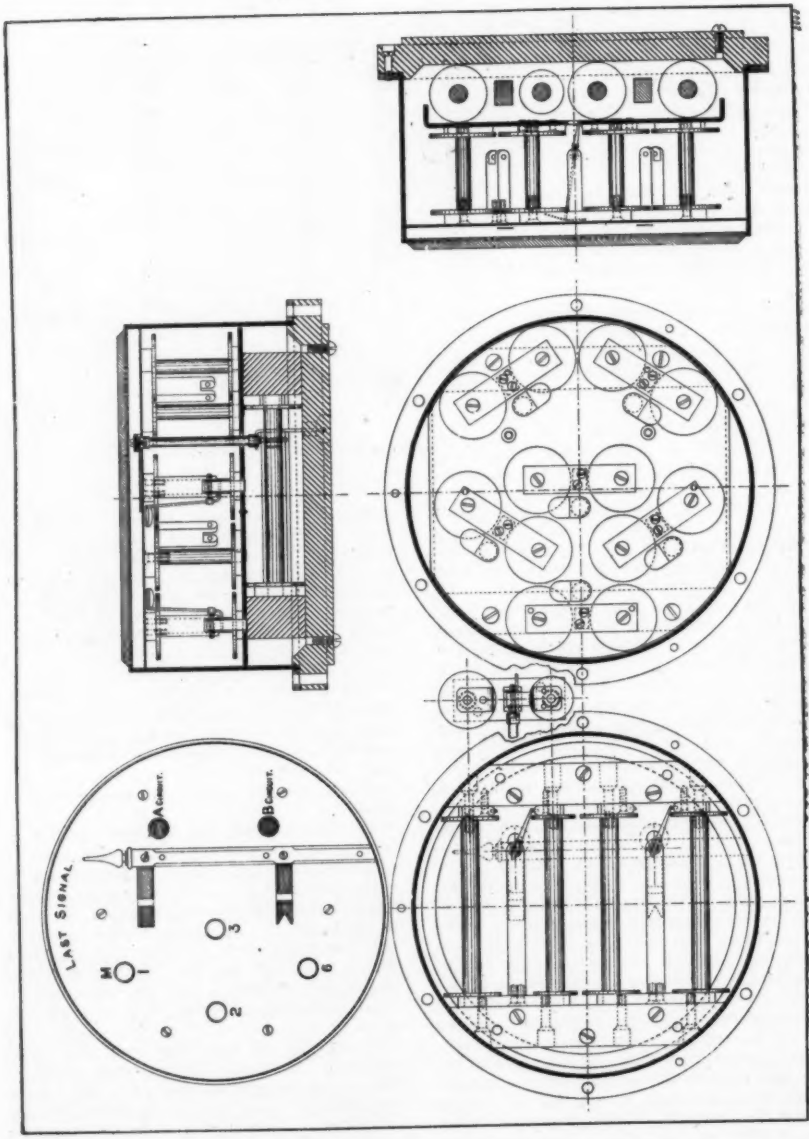


FIG. 2.—SIGNAL INDICATORS: BOULT'S SYSTEM OF RAILWAY SIGNALLING.

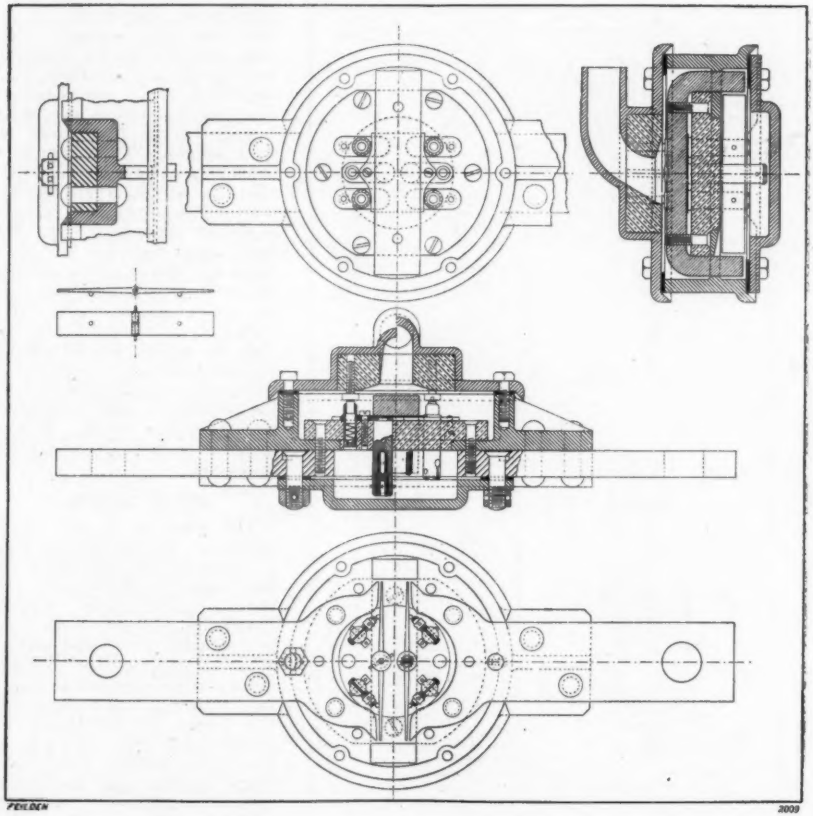


FIG. 3.—ARMATURE RELAYS: BOULT'S SYSTEM OF RAILWAY SIGNALLING

thrown in one direction comes against an insulated contact post and thus closes one electric circuit on the engine, and when thrown in the opposite direction, similarly closes another circuit. When away from the influence of road magnets, it is magnetically, or otherwise, held in the middle of its travel, and clear of both contact posts. The action is that of the well-known polarised relay, the road-magnets and armature taking the place of the electro-magnets in the instrument used in telegraphy.

With the means of closing either of two independent local circuits (on the engine) thus provided, practically any signals preferred can be given and if desired recorded.

Mr. Boult's apparatus, after having passed through the unavoidable modifications of the experimental stage, has at present reached the form indicated in the diagrams accompanying this sketch, and the somewhat summary description necessitated by the exigencies of space.

INDICATOR.

The design shown in Fig. 2 has been recently completed. The movements are all of the polarised type, so that the various indications may be magnetically held on or off after the operating current has ceased. Each movement comprises a combination of two coils and an intermediate permanent magnet carrying a pivoted armature tongue; the two coils are energised separately. As the apparatus will work with a very small

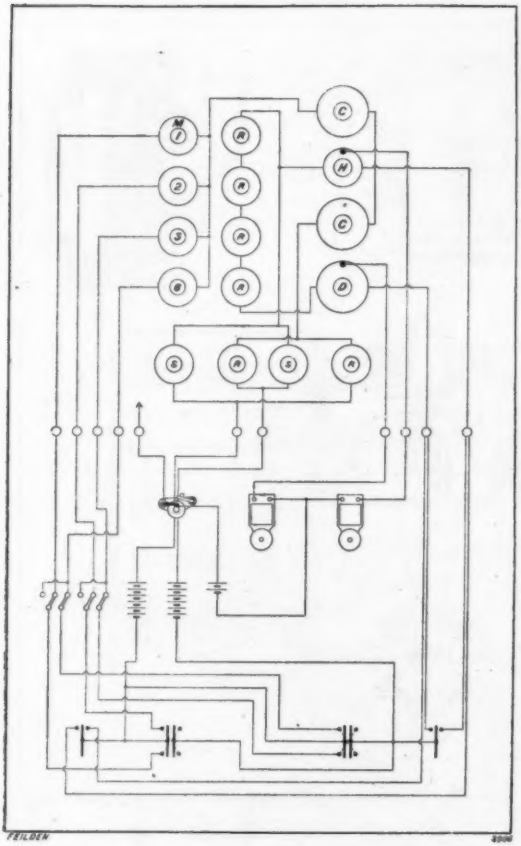


FIG. 4.—ENGINE CIRCUITS FOR COMPLETE SIGNALLING: BOULT'S SYSTEM.

current, it becomes possible to operate the indicator with great safety. In Fig. 2 the dial of the indicator, with home and distant semaphores, duplicate action spots, and four number holes for indicating the road made at junctions, is shown. The same figure gives diagrams of the permanently wired base of the instrument, with radiating contact springs for connecting up the indicator coils.

ARMATURE RELAYS.

Fig. 3 shows the construction of the armature relay. The ends of the whole structure or bridge-piece shown are attached to longitudinal pole-plates as shown in the right-hand diagram of Fig. 1. Both the iron needles, 3 ins. long (see the lowest diagram in Fig. 3), are polarised and controlled by a single horse-shoe magnet, which to a large extent relieves the pivots of their weight. There are four contact posts, against each of which a needle, when thrown over by road-magnets makes duplicate contact, so that for each signal there are four contacts, any one of which suffices for working. Connections with the circuit wires are made at the back, or upper side, of the ebonite slab, on which the movement is mounted, by means of plungers, such as are used in lamp-holders, and insulated screws in the cover. Everything is enclosed in a jointed brass box.

ENGINE CIRCUITS.

The working of the whole apparatus is illustrated in Fig. 4, where the connections of all the parts on the engine are shown. The upper portion shows the indicator coils connected with their terminals—a row of small circles. In the lower portion are seen four armature relays carried underneath the engine, as also shown in the left-hand diagram of Fig. 1. The two outside ones have single needles only, and work in duplicate to give the "danger" signals. The other two armatures have duplicate needles, and give the "line clear" signal in conjunction with one road number. There are two batteries with their positive poles connected through the two coils of the "push relay" to the two "duplicate action," or spot, movements, and their negative poles connected to the armature needles, so that for each signal one needle in connection with each battery is operated. The numbers *M* 1, 2, 3, 6, indicate the respective coils for showing these numbers on the dial. *H* and *D* are the home and distant danger coils. *C C*, working together, give the "line clear" signal. *S S* show duplicate action spots in connection with "danger" signals, while the coils *R* are for replacing the numbers and spots.

ROAD CIRCUITS.

Fig. 5, which shows the arrangements at

a junction, each branch of which leads to another junction, and in which equivalent road-semaphores are also shown, represents schematically the complete arrangement for signalling. Permanent magnets are shown by single and electro-magnets by double circles. It will be seen that at each signalling station the engine first gets the "danger" signal—distant or home, as the case may be, according to the polarity of the permanent magnets—immediately followed by "line clear," and a road number, if current is in the electro-magnets. If current is not on, the "danger" signal only is taken. The apparatus for giving the "danger" signals is in duplicate. Incipient failure of the apparatus would be shown while the running signals are still being correctly taken. If there should be failure of current on the road the signals are set automatically at "danger." There is no current wasted during the normal condition of "line blocked." The engine receives signals correctly when running either end first. Finally, the expenses for maintenance are very small.

In consideration of these facts it is easily comprehended that Mr. Boult's system should be thought of highly by those best entitled to judge; and among the latter we may mention, above all, Mr. James Swinburne, who, after having carefully examined the system, has reported on it in very favourable terms, which induces us to hope that Mr. Boult's invention will in the near future find practical application on our railways. Although the initial outlay involved in fitting railways with Mr. Boult's system would doubtless be very heavy, the greater safety of passengers and the fewer accidents which would occur, especially in murky weather, would more than compensate for this large expenditure.

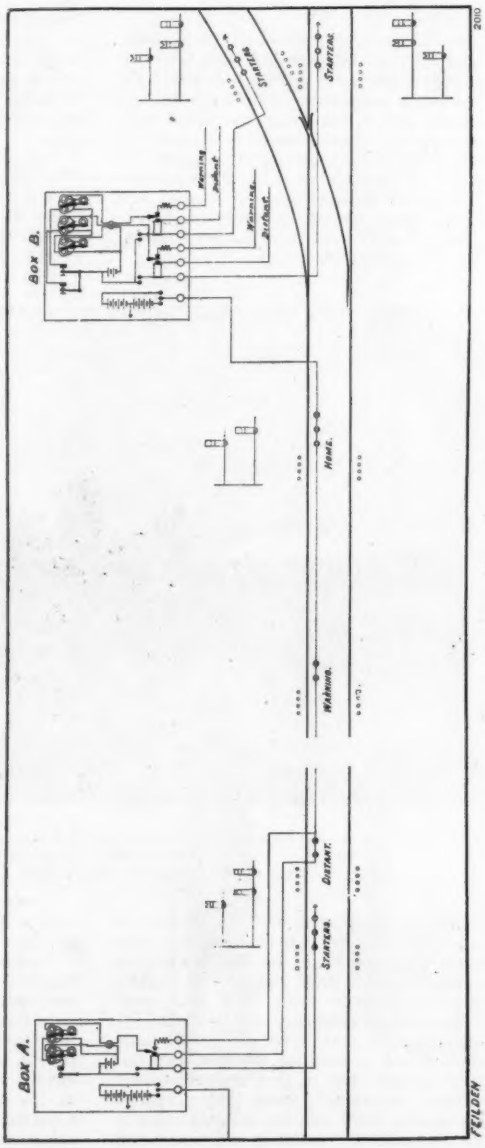
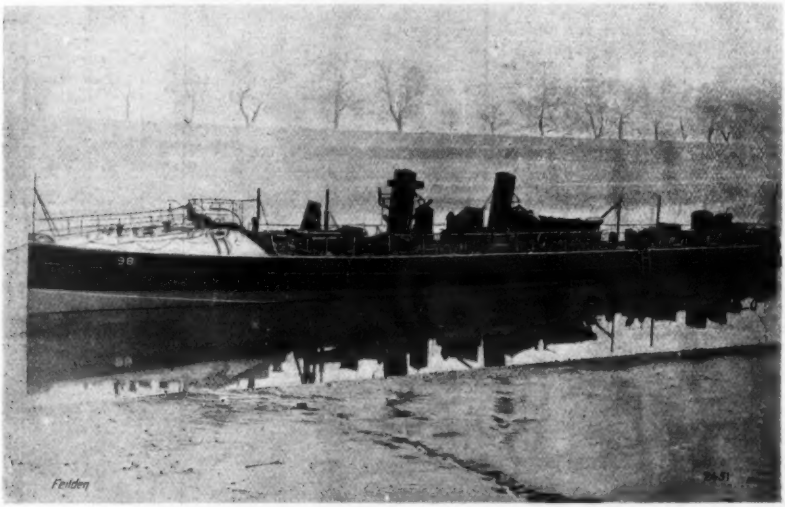


FIG. 5.—SCHEME OF COMPLETE SIGNALLING ARRANGEMENTS: BOULT'S SYSTEM.

NEW TYPE OF TORPEDO-BOAT.

IT has been the policy of the British Admiralty to improve the destroyer of torpedo craft for several years now. In the last Naval programme, however, a change was made, and it was there laid down that a new departure should be made in torpedo-boats. Orders were subsequently given to Messrs. J. I. Thornycroft & Co. to build four new first-class torpedo-boats of a new and heavier design ; one of the conditions being that they should carry a load 20 per cent. in excess of that for a destroyer.



NEW TYPE OF SINGLE-SCREW TORPEDO-BOAT (NO. 98) SPECIALLY BUILT FOR H.M. NAVY BY MESSRS. J. I. THORNYCROFT AND CO., CHISWICK.
Length, 160 ft. ; Beam, 17 ft. ; Draught, 8 ft. 5 ins. ; I.H.P. 2,800.

It was in accordance with the fitness of things that the firm which built the first torpedo-boat, the *Rasp*, for the Norwegian Government, and thus started the world's flotillas of torpedo craft, and also built the first, the *Lightning*, for the British Government, should have placed in their hands the task of building the first torpedo-boat under the lines of this new departure. As before mentioned, these later torpedo-boats are to carry heavier weights than is usual for a destroyer ; but they are intended also to have considerable cruising radius, as bunker capacity is to be supplied for 40 tons of coal. They are, as will be seen from the figure, of larger proportions and greater strength than usual, which will enable them to maintain their speed in rough weather better than the present boats do in smooth. The larger size also allows the builders to fit in larger and more powerful engines than have ever been fitted in torpedo-boats before.

The dimensions of this torpedo-boat (No. 98) are :—Length between perpendiculars, 160 ft. ; beam, 17 ft. ; while they draw at maximum load 8 ft. 5 ins. of water. They are to be 25-knot boats, which is the highest speed for torpedo-boats on the Admiralty list, and the load is to be 40 tons.

Looking through the list of French torpedo-boats of the first class, it will be noticed that only those which were first built were fitted with single screws. The policy in later times has been to build twin-screw torpedo-boats for the French Navy. But the policy of the British Admiralty, and it has been followed in this as in most other things by the Russian Government, has been to build single-screw torpedo-boats. Only one twin-screw torpedo-boat has been built for the British Admiralty, and only one for the Russian Government.

One or two of the other governments have had built several boats with twin-screws, but it is not the practice. The British Admiralty have continued their policy of single screws for the new type of torpedo-boat, although the power to be put into them has enormously increased. The boat has also been designed with the Thornycroft stern and the balanced single rudder.

She is a larger boat, and she has been assigned a larger complement than has ever been placed on such craft before. The complement is 32 men and officers. A search-light projector has been fitted on the conning tower, and the lower decks are built of wood.

The armament consists of three 3-pounder quick-firing guns, two broadside torpedo-tubes, and one torpedo-tube aft each to fire a Whitehead 18-in. torpedo.

The engines are large and powerful for this kind of craft, and are of the Thornycroft patent balanced type with inclined cylinders, which have proved to be very free from vibration in the destroyers constructed by the firm. It is the first time they have been fitted into torpedo-boats. They are designed to indicate about 2,800 horse-power when the pressure is 220 lbs. per square inch, and the revolutions of the shaft are 400 per minute. The utmost care has been taken to balance the engines, and there is hardly any vibration even at the stern, which absence of vibration is very marked as compared with some of H.M. destroyers.

This feature is of great advantage to the officers, as they complain often of the shaking to which they are subjected in their quarters aft. In these boats the officers' quarters will be unusually comfortable.

No. 98 has to undergo the following trials:—

Three hours' coal consumption at 25 knots, and afterwards a further three hours' trial at the same speed. Finally, 12 hours' coal-consumption trial at cruising speed. On Monday, January 28th, she made a successful preliminary trial with all weights on board.

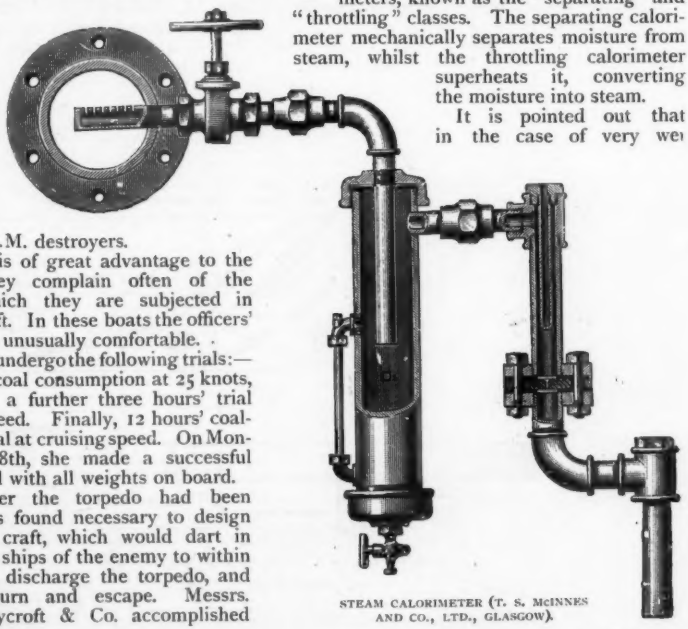
In 1873, after the torpedo had been invented, it was found necessary to design a fast moving craft, which would dart in towards the big ships of the enemy to within about 500 yds., discharge the torpedo, and then quickly turn and escape. Messrs. John I. Thornycroft & Co. accomplished this by building the small *Rasp*, which was 58 ft. in length, 7 ft. 6 in. in breadth, and 3·9 ft. draught. Later, in 1876, they designed one of larger dimensions and greater speed for the British Government—the *Lightning*. The advance which has been made is best shown in tabulated form :—

	Rasp, first torpedo boat for Norway.	*Lightning*, first torpedo boat for Gt. Britain.	No. 98, new type of torpedo boat.
	1873	1876	1901
Length	58 ft.	85 ft.	160 ft.
Breadth	7·5 ft.	10·9 ft.	17 ft.
Draught	3·9 ft.	5 ft.	8·4 ft.
Displacement	16 tons	27 tons	178 tons
i.h.p.	—	460	2800
Speed	18 knots	19 knots	25 knots
Armament	—	—	3·3 prs.

THE McINNES CALORIMETER.

THE steam calorimeter we describe is a compound of two types of calorimeters, known as the "separating" and "throttling" classes. The separating calorimeter mechanically separates moisture from steam, whilst the throttling calorimeter superheats it, converting the moisture into steam.

It is pointed out that in the case of very we



STEAM CALORIMETER (T. S. McINNES AND CO., LTD., GLASGOW).

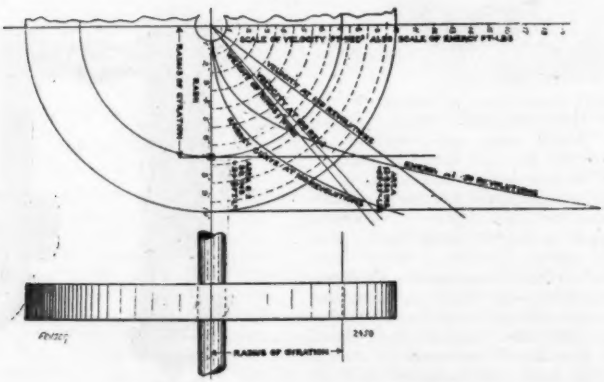
steam, the throttling calorimeter will not be suitable, as the heat given out may not be sufficient to cause its entire conversion. In the separating calorimeter, on the other hand, the moisture clings to the walls of the chamber, and then trickles down to the bottom, where it accumulates, and can be drawn off and weighed. The steam which passes through must be condensed and weighed. In the throttling calorimeter the steam passes through a very small orifice, and is reduced ordinarily to atmospheric pressure, or nearly so. The total heat in the steam at the higher pressure is greater than the total heat in the steam at the lower pressure, hence a quantity of the heat is set free, and it is this heat which causes the conversion of the mechanically suspended globules of water into steam.

The calorimeter made by Messrs. McInnes & Co., Ltd., combines in itself both systems, and is fitted with both a separating chamber and a throttling orifice. When desired, however, the separating chamber and the throttling orifice may be used separately.

The amount of priming water present in steam can be conveniently and correctly ascertained by both the separating and the throttling systems, the separation test, however, being the simpler of the two, with the assistance of a small mathematical formula.

A NEW TYPE OF WAGON BRAKE.

THE new wagon brake (illustrated in Figs. 1-5) has been patented under the name of "W. S. Laycock's Either-Side Wagon Brake," and is designed so as to comply with the requirements laid down by the Railway Companies and the Board of Trade. While the old-style side lever, with which every railway employé is familiar, has been retained, there are several noteworthy improvements to be mentioned. It can be applied or released from either side of the wagon, and this, moreover, is accomplished by one operation only, which requires the use of but one hand. Owing to the great simplicity of its construction, it is not likely to get out of order. There are no balance weights or springs on the brake gear required to counteract the weight of the levers. One of the advantages of the Laycock brake is that the brake-mechanism can be readily fitted, with the ordinary side lever, to the specification sent by any private owner. Among the characteristics of the new brake, is an ingenious but simple device, for retaining each brake lever when the brake is off. All these features are worthy of attention, and if the claims of the inventor find their confirmation in practical experience, his patent is sure to bring him considerable financial reward, for there is a great demand for a reliable and effective brake, which is of simple construction and easy to operate.



THE ENERGY OF A ROTATING BODY (*see page 468*).

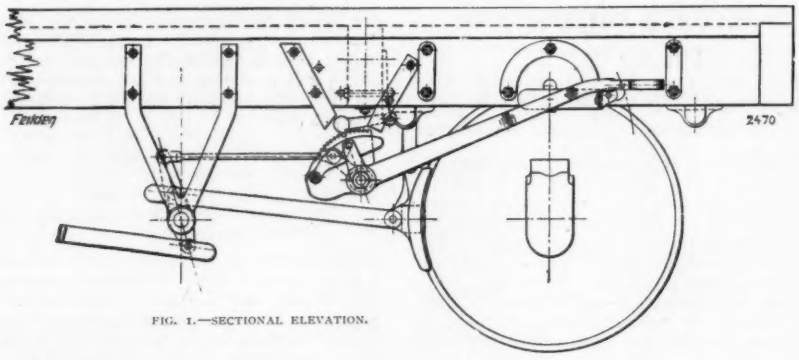


FIG. 1.—SECTIONAL ELEVATION.

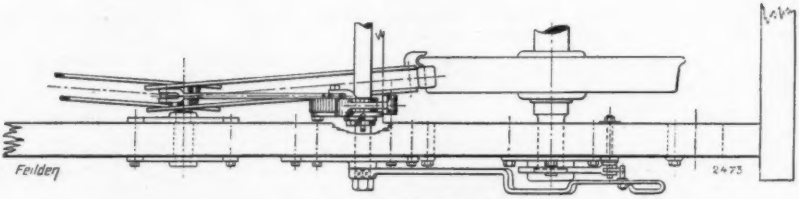


FIG. 2.—SECTIONAL PLAN.

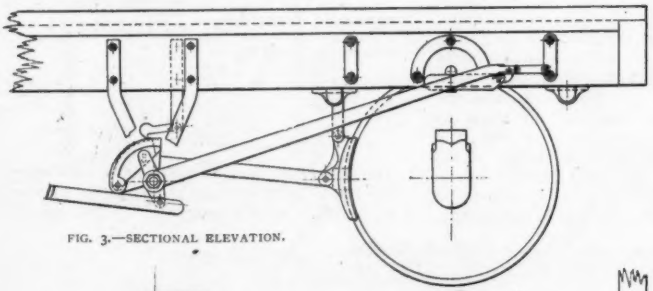


FIG. 3.—SECTIONAL ELEVATION.

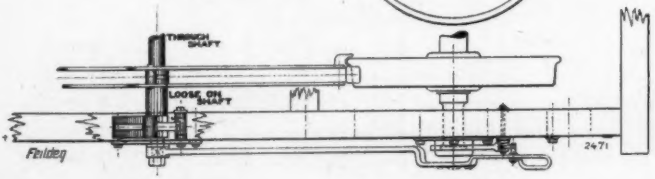


FIG. 4.—SECTIONAL PLAN.

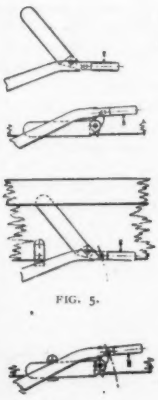


FIG. 5.

DETAILS OF LAYCOCK'S PATENT EITHER-SIDE WAGON BRAKE

ENERGY OF A ROTATING BODY.

THE energy which a body possesses, due to a motion of translation, is expressed by the formula $\frac{WV^2}{2g}$, where W = weight, V = velocity in ft.-secs., and g = acceleration due to gravity. When a wheel or disc is rotating about its axis, this formula cannot be used unless a correct value be given to V, viz., that of the centre of gyration. This centre of gyration can be readily found as follows: imagine a disc of wrought iron, 2 ins. thick and 20 ins. diameter, revolving at a speed of 100 revolutions per minute. Further, imagine this disc made up of nine rings, each 1 in. deep, then the speed, weight, and kinetic energy of each ring is tabulated below and given graphically on page 466.

We want to find a certain radius (K), called the radius of gyration, such that if the whole weight of the disc, if concentrated at this radius and revolving at 100 revolutions per minute, will possess the same kinetic energy. Proceed thus:—

$$\frac{WV^2}{2g} = 24{\cdot}8 \text{ ft.-lbs.}$$

$$\therefore V = \sqrt{\frac{24{\cdot}8 \times 64{\cdot}4}{40{\cdot}8}} = 6{\cdot}25 \text{ ft.-secs.}$$

Referring this to the velocity curve, we find a point situated at 7·07 ins. radius possesses this velocity, and this point is the radius of gyration. If the speed of the disc be increased to 150 revolutions, we get another energy curve constructed from the data tabulated below.

The total area under this curve = 13·8 sq.-ins., and $13{\cdot}8 \times 4 = 55{\cdot}2$ ft.-lbs. Proceeding as we did in the former case:—

$$\frac{WV^2}{2g} = 55{\cdot}2 \text{ ft.-lbs.}$$

$$\therefore V = \sqrt{\frac{55{\cdot}2 \times 64{\cdot}4}{40{\cdot}8}} = 9{\cdot}34 \text{ ft.-secs.}$$

and the point (radial) possessing this speed is shown from velocity curve to be 7·07 ins. as before. If this quantity (K = 7·07 ins.) be

FOR 100 REVOLUTIONS PER MINUTE.

Radius.	9½	8½	7½	6½	5½	4½	3½	2½	1½	inches.
Speed.	8·3	7·42	6·55	5·67	4·8	3·92	3·05	2·18	1·31	ft. per sec.
$\frac{WV^2}{2g}$	8·3	5·94	4·2	2·65	1·52	·88	·4	·155	—	ft.-lbs.
Weight of ring 1 in. deep.	7·75	6·95	6·14	5·3	4·5	3·68	2·86	2·1	1·23	lbs.

The total energy of revolving disc is of course the sum of the energies of each ring, and as the energy at the *centre* of each ring has been tabulated, this will be approximately correct. In the figure these energies have been plotted to a scale of 2 ft.-lbs. = 1 in., and the area under curve is found to be equal to 6·2 sq. ins.; and as 1 sq. in. = 4 ft.-lbs., the total energy = $6{\cdot}2 \times 4 = 24{\cdot}8$ ft.-lbs. This energy of course is the total energy due to the weight of the disc (40·8 lbs.) revolving at a uniform speed of 100 revolutions per minute.

FOR 150 REVOLUTIONS PER MINUTE.

Radius.	9½	8½	7½	6½	5½	4½	3½	2½	1¼	inches.
Speed.	12·4	11·13	9·82	8·5	7·2	5·88	4·57	3·27	2	ft.-secs.
$\frac{WV^2}{2g}$	18·5	13·4	9·2	5·93	3·63	1·98	·97	·35	·2	ft.-lbs.
Weight of ring 1 in. deep.	7·75	6·95	6·14	5·3	4·5	3·68	2·86	2·1	1·23	lbs.

squared and multiplied by the volume of the disc, thus :—

$$(7\cdot07)^2 \times d^2 \times \cdot7854 \times 2 \text{ ins.}$$

a quantity is arrived at which is known as the moment of inertia of the disc, and as moments of inertia for solids of various sections may be found in almost any engineering pocket-book, the simplest way to find the radius or centre of gyration of any revolving body is to divide the moment of inertia by the volume, and extract the square root. Or in symbols—

$$K = \sqrt[2]{\frac{I}{M}}$$

For a disc such as we have been considering, I is given as $\frac{MR^2}{2}$

$$\therefore \quad K = \sqrt[2]{\frac{MR^2}{2M}} = \frac{R}{\sqrt{2}} = \frac{R}{1\cdot414}$$

and as R = 10 ins.,

$$\therefore \quad K = \frac{10}{1\cdot414} = 7\cdot07 \text{ ins.}$$

as previously found.

DODD'S PATENT AUTOMATIC APPARATUS

FOR CONTROLLING STORM WATERS, COMPENSATION WATERS, FLOW OF SEWAGE.

IT is very often found necessary, in the case of sewerage works, to be able to regulate the maximum amount of sewage passing down the sewer from any given area, so that the flow is automatically checked if it exceeds a certain maximum rate. In cases where there are several outlying districts within the watershed contributing to a joint drainage area, a difficulty is often experienced by the corporation in regulating the amount of infiltration and storm waters allowed from each district, so that the maximum amount permitted shall not be exceeded.

It is claimed that this Automatic Apparatus will effectually govern the flow of such waters, instantly checking the flow when the maximum rate is exceeded by however small a quantity. It will be found useful for preventing pollution to rivers, and in waterworks schemes as regards compensation waters.

Messrs. Glenfield & Kennedy, Kilmarnock, are the sole manufacturers. The

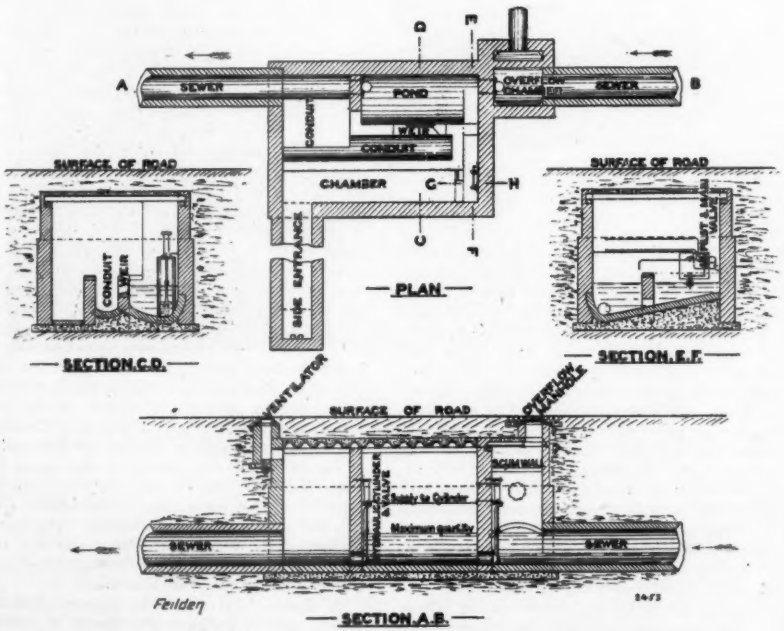


FIG. 1.—DODD'S PATENT APPARATUS FOR CONTROLLING STORM WATERS.

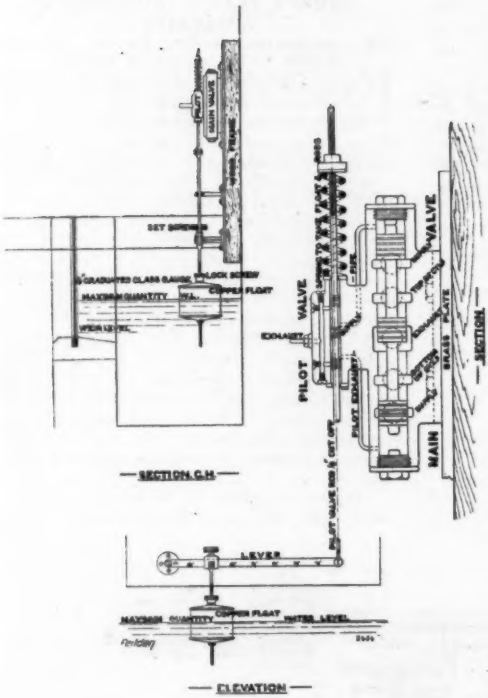


FIG. 2.—DODD'S PATENT APPARATUS FOR CONTROLLING STORM WATERS: DETAILS OF VALVE ACTION.

inventor, Mr. Edward Dodd, Civil Engineer, 37A, Waterloo Street, Birmingham, will be pleased to supply any further information.

On reference to figure, it will be seen that a chamber is constructed as shown on plan and section A.B., which is built upon the existing sewer and is again divided into compartments, consisting of overflow chamber, pond, and float chamber. The overflow chamber is provided with a scum wall, to prevent any floculent matter passing to the overflow pipe. In this chamber is also fixed the hydraulic cylinder and valve which will regulate the supply of sewage into the pond. The object of the pond is to get a large area of water without velocity before it passes over the weir gauge. In the pond is fixed a hydraulic cylinder and valve, which will only be opened for cleansing purposes, or when it is not necessary to pass the sewage over the weir gauge; in that case the sewage will pass in a direct line through the two gates.

In the float chamber shown on plan, section E.F. and G.H., there is also a scum wall to further steady the water. In the chamber a copper float will be fixed on a lever, which float will be free to rise or fall according to the depth of water passing over the weir gauge. The lever is connected to the piston rod of the pilot valve which controls the main valve and regulates the supply of water to the hydraulic cylinder in the overflow chamber, thus closing or opening the gate. In the float chamber is built into the wall a graduated glass plate, marked in 16ths of an inch above a datum line which corresponds with the level of the cill of the weir gauge, so that all reading will be taken from this plate of the depth of sewage passing over the weir gauge.

When it is found necessary to allow a greater quantity of sewage to pass over the weir gauge, owing to the increase of the population, it is only necessary to screw up the float to the required height.

If any record is required of the quantity of sewage passed over the weir gauge per 24 hours, then the patentee suggests that the Glenfield Company's Automatic Recording Apparatus be fixed in the float chamber, H.120 in catalogue. When the maximum quantity of sewage has been decided upon and the depth it represents passing over the weir gauge, the float is fixed to this level by means of a lock-nut screw on a screwed rod, which passes through the centre of the float, and can be set to any desired cut-off. In the drawing it is shown to a cut-off of $\frac{1}{16}$. Should this maximum quantity be exceeded by an amount representing an extra depth of say $\frac{1}{32}$ of an inch over the weir gauge, the float will rise, raising the lever which is connected to the piston rod of the pilot valve, thus closing or partially closing the sluice gate and checking the flow of the sewage.

Again, when the sewage in the pond has subsided, say $\frac{1}{32}$ of an inch, the float will fall, and so reverse the action of the valves, causing the sluice gate to re-open. The spring shown on the top of the pilot valve is to take up the dead-weight of the float and rods, and thereby assist the float to work.

A throttle valve on the exhaust from the main valve regulates the speed of the hydraulic cylinder valve in the overflow chamber to any desired rate.

When it is required to flush out the sewer and pond, it is only necessary to close the cock on the exhaust pipe from the hydraulic cylinder in the pond and open the supply, the gate will then open and allow the sewage to flow down the sewer instead of over the weir gauge. This order of things will be reversed when it is required to pass the sewage over the weir gauge by closing down the gate in the pond. The float could be of course fitted direct to the rod of the pilot or main valve, if the lever should be considered to be too delicate.

NEW PATENT BARGE LIFT.

NEW PATENT BARGE LIFT.

THE subject of the Supplement Plate this month is Messrs. Thomas's Patent Barge Lift, Tanks and Machinery for which were designed and manufactured to the order of the Grand Junction Canal Company, under the direction of their engineer-in-chief, Mr. Gordon Gale Thomas, and Mr. B. James Thomas, the inventors, by Messrs. J. & H. Gwynne, Ltd., 81, Cannon Street, E.C., and Hammersmith Iron Works, W. It is erected at Foxton, Leicestershire, its object being to improve upon the duty formerly rendered by a staircase of ten locks. The difference of level between the two canals is 75 ft., and among advantages over the old method of locking claimed for the new system, are: first, a great saving of water, approximating to 90 per cent. of the quantity used by the lockage system; second, the time occupied for the passing of two boats in each direction, an operation which is now effected in twelve minutes, as compared with one hour fifteen minutes under the old system.

As to the cost of working, the duty, taking fifteen minutes' intervals between the operations, is 6,000 tons per day of 12 hours, and the cost of dealing with this tonnage, based on the actual experience of the past six months, is placed by the inventors at £1 4s. 6d. per day, including coal, oil, stores and labour.

The plant consists of two movable tanks, two fixed conduits, hydraulic gates and rams, steam-engine and boilers, hydraulic pumps,

accumulator, steel wire ropes, hauling drums, guide pulleys, &c.

The two movable tanks are built of steel plates, each tank being mounted upon eight sets of wheels, running on four pairs of rails laid upon an inclined plane, the grade of which is 1 in 4.

The two fixed conduits form ends for the upper canal to support the necessary gates and face fits. Each movable tank is 80′ × 15′ × 5′ inside, and is capable of taking two 33-ton canal boats, or one barge carrying 70 tons. The movable tanks are connected by 7-inch steel wire ropes passing round the guide pulleys and hauling drums; consequently, when one tank ascends the other descends, thus balancing each other, the engine simply having to overcome the friction of the moving parts.

When a boat has to be raised it is floated into whichever tank is at the lower level, through a suitable gate at the end, the water in the tank being, of course, at the same level as that in the canal. The gate is then closed by means of hydraulic cylinders, and the tank is hauled up the incline with the boats still floating; the boats being thus water-borne during the whole operation, are consequently not strained in any way.

While the tank ascends, a corresponding tank descends, which, being full of water, sustains a balance, it being immaterial to the balancing whether there are boats in both tanks or not, as the total weight under any condition of loading is maintained at an equality.

Upon arrival at the top of the inclined plane, the movable tank is held in position by means of hydraulic rams; the gate at the other end is then raised simultaneously with the gate of the fixed conduit, thus making the connection with the canal at the higher level.

In order to save manual labour, the gates of the tanks and conduits are raised and lowered by hydraulic power.

The engine for driving the main hauling drums and working the hydraulic plant is of the double-cylinder high-pressure jet-condensing type, the power being transmitted to the drums by means of powerful worm gearing. The boilers are of the Lancashire type, two in number; one, however, being of ample power to do the work, the other is simply held in reserve.

The hydraulic pressure is obtained from a horizontal duplex pump, having outside bucket plungers. This pump delivers into an accumulator, which is sufficiently large to hold a reserve of water to work all necessary cylinders simultaneously.

The Lift is capable of passing from 150 to 200 ordinary canal boats in 12 hours of continuous working, and the whole plant can be worked by three men.

PRACTICAL ARTICLES FOR PRACTICAL MEN.

THE GAS ENGINE, BY JAMES HALL.

(Continued from page 381.)

To ensure uniformity and smooth working all cams should be milled. A popular form of cam miller is shown by Fig. 12, and is made by same makers as flywheel lathe (Messrs. Smith & Coventry).

The view shows an internal cam fixed in machine. The cross slide is controlled by a steel bowl fixed in front of screw and acting on a "dummy" or shaper cam. The bowl is always kept hard on shaper cam by a weighted lever, acting through gearing to a rack under cross slide. The whole machine is very strongly built, and cams may be cut quickly and accurately by it.

Special care should be bestowed on crank shaft whilst it is being turned on crank pin and also on bearings. They must be true, or endless trouble will result, through constant heating up of brasses. Connecting rods must have crank and piston pin-holes bored out parallel. Piston pins are best hardened and let in piston from grinding machine. Connecting rods and valve spindles along with all lever studs require to be of very good steel, if long life and good working are desired.

Any steel cams of bowls used should have hardened faces and bearing holes.

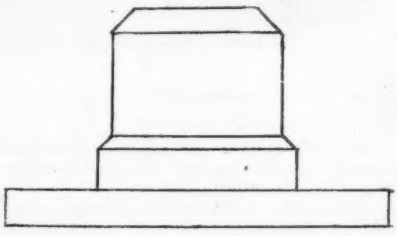


FIG. 10.—TEMPLATE FOR CYLINDER BEARER.

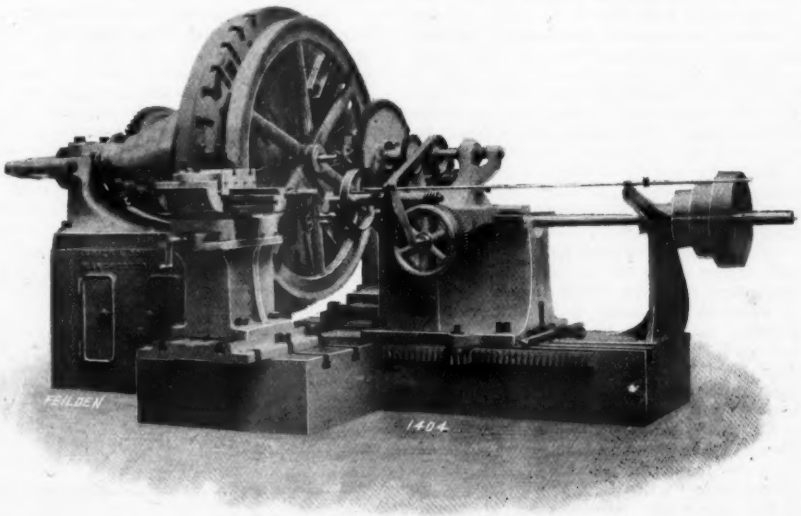


FIG. 11.—TREBLE-GEARED LATHE FOR TURNING FLYWHEELS AT LOW COST.

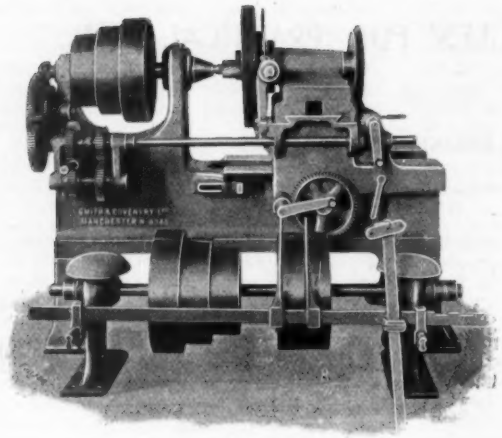


FIG. 12.—MILLING MACHINE, SPECIALLY SUITABLE FOR CAMS.

After all machine work has been done upon various parts of engines, they are sent forward into the erecting shop.

Whilst the crank shaft is being bedded into its bearings the bed of engine should be raised up to position shown in Fig. 13. As most crank caps are at 45 degs. on bed, a satisfactory bedding of shaft can only be accomplished when bed is raised as shown. It should be seen that the brasses are easy from crank at joints, and that they have good cross grooves in them for oil to travel down. Same points should be observed when connecting rod brasses are being bedded down to crank pin. Too much care cannot be taken with these bearings.

When fly wheels of large diameter and considerable weight are used, two keys are required to secure them to the shaft, and must be of good fit.

Levers which are used for working valves and driven from lay or side shaft, should have their studs on which they swivel let in so as to be parallel with shaft, or a bad working valve will be the result. Long springs for holding lever bowls to cams are desirable. A spring should not be compressed or stretched above one-fifth its length.

All valves must be thoroughly ground to their seatings. A convenient and very common reamer is shown by Fig. 14 for giving correct mitre.

The governor requires very accurate fitting in all its parts, especially when it is of the centrifugal type. It requires to be free, and at the same time have no slack or shaky parts.

The setting of the cams for working valves may now be dealt with :—

The air cam should be open all the taking or charging stroke as shown by crank circle in Fig. 15. A represents position of crank pin air valve open ; A^1 same when closed.

The gas valve should be open at position B, and remain open through 90° to position B^1.

This may require to be exceeded if quality of gas is poor or area of valve is small.

The exhaust cam should be set to open valve in position shown in Fig. 16 ; C being position of crank pin when valve opens ; C^1 same when closed.

The ignition or timing valve is best set to open on crank in centre, and be only closed during compression stroke. When engine is not arranged with a timing valve, length of tube or position of flame on tube must be adjusted to fire a little after "in" dead centre is passed.

After cams are set, their position must be marked on shaft, and the teeth of skew gear marked to ensure wheels being geared in right teeth.

A general examination should be made of engine before sending to running and testing shop ; "Fins," if any are found in valves or passages (and been missed in dressing shop), removed, along with any grit or sand, little details which, when forgotten, have sometimes given a lot of unnecessary trouble.

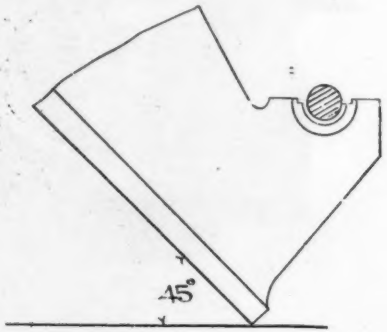


FIG. 13.—ENGINE BED RAISED TO FACILITATE FIXING CRANK-SHAFT IN ITS BEARINGS.

RUNNING AND TESTING.

On receiving engine in testing shop, it should first be turned round by hand to see that all parts clear. Afterwards it should be seen that all lubricators are filled ; if worsted syphons are used, see that worsted is not too tight in tubes, so choking feed.

It is always advisable to run engines some considerable time by belt from line shaft. A very large part of the "stiffness" may be taken out by this means before running under gas.

Freely oil the piston ; in fact, all parts should be gone over at intervals whilst engine is running.

The crank-pin and shaft bearings should be watched, as in some cases they will heat up very rapidly even whilst running under belt.

When it is found that engine has run itself fairly easy, belt may be thrown off. The piston should now be drawn, cleaned, and rings examined. If they are "coming on" satisfactorily, lines can be wiped out, piston oiled and replaced.

Chief bearings should also be looked at, and any hard places nicely eased. Side shaft and other bearings should not be forgotten.

If all is now satisfactory, the indicator tackle may be fixed, and engine coupled to gas and other pipes. A handy form of indicator tackle is shown by Fig. 17.

The water supply should always be from a tank or tanks. A running supply of cold water is not desirable, for reasons which will be explained later.

Engine being still rather too stiff for turning by hand, starting-belt can be used again with advantage.

When ignition tube is sufficiently heated, gas should be turned on, and immediately engine commences to "fire," belt thrown off.

After having run under gas for a short period, all bearings should again be gone over ; heating up of same is now more likely than when running under belt.

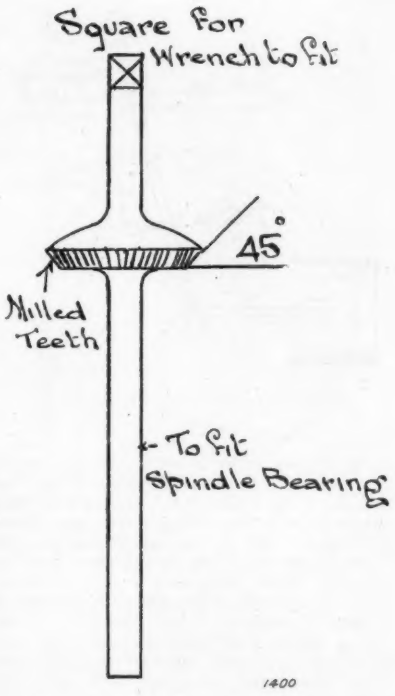
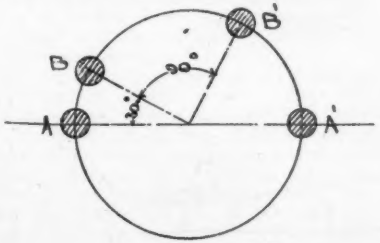
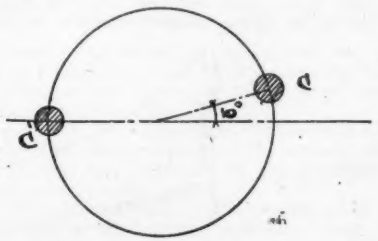


FIG. 14.—REAMER FOR GRINDING VALVE SEATINGS.

When thoroughly satisfied with behaviour of piston rings, bearings, etc., an indicator card should be taken with engine running by itself, that is, "light."

If valves have been set to diagrams n previous section, the card should appear as Fig. 18, *i.e.*, firing late. This is a good diagram for any engine when running "light."





FIGS. 15 AND 16.—METHOD OF SETTING CAMS FOR OPERATING INLET AND EXHAUST VALVES.

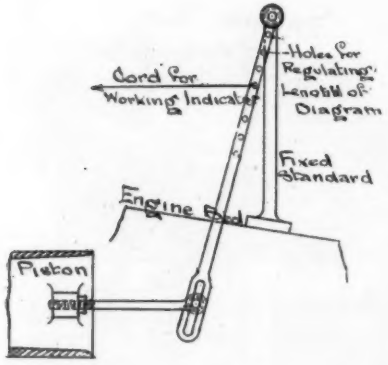


FIG. 17.—INDICATOR TACKLE FOR GAS ENGINES.

If ignition valve is set to fire any earlier than shown, there is always a danger of engine firing before "in" centre is reached when under a load, owing to liner and valves getting hot with the constant explosions, and very often this early firing pulls up the engine. Apart from this, a card, as shown, does away with a considerable amount of "thud," brought by sudden shock on piston.

An engine should always have a long run under gas both with and without load before it is tested for full power and gas consumption.

The best results cannot be obtained until after at least four weeks' constant running. In fact, makers generally stipulate a certain brake h.p., at so many cubic feet per brake h.p. per hour, after one month's running, and these results under gas of 16 c.p.

A very convenient and simple form of flywheel brake is shown by Fig. 19.

The "Prony" brake, as shown in Fig. 20, is used very largely on the Continent. For what reason the writer cannot say, as it requires a considerable amount of watching whilst being used, and very accurate readings of the spring balance cannot be made, as they are so irregular. Again, water has to be freely used on the friction pulley, to prevent firing of wood blocks.

The brake marked Fig. 19 consists of two lengths of rope passing around wheel, one end being secured to a spring balance suspended from ceiling or roof of engine-house, the other carries weight-holder and weights. Metal clips are fastened at intervals on ropes to keep same in position on wheel. This brake may be run for several hours on prepared wheels for testing purposes, wheels which have flanges cast on inner side of rim, for carrying water. An hour is a safe limit for a brake load to be on an ordinary flywheel, or safer still, brake should be eased when flywheel is too hot for the hand to be held on.

When an engine is to be put under brake test, a diagram should be first taken. Then brake-strap put on, and weights until full load is reached. That is, say when one charge is cut out after every nine or ten explosions. If test is for thirty minutes only, six cards should be taken, one every five minutes. The negative back pull recorded on spring balance should be taken at same intervals. The reading on gas meter must be noted also, and at frequently timed intervals.

After the run the brake h.p. may be calculated, the mean nett weight hanging on wheels being taken, *i.e.*, weight of ropes and weights on holder, less average back pull, through a distance equal to circumference taken through centre of ropes, and this multiplied by revolutions per minute. This total, divided by standard number of foot pounds taken to equal one h.p. (33,000), will give us total brake load on wheel. The number of brake h.p. developed, divided into total number of cubic feet of gas consumed per hour (gas only having been taken for 30 minutes' consumption, would be assumed to be just doubled in the hour), gives gas consumption per brake h.p. per hour.

$$\text{Or } \frac{\text{nett wt. in lbs.} \times \text{circum. of brake in ft.} \times \text{No. rvs. min.}}{33{,}000} = \text{Brake h.p.}$$

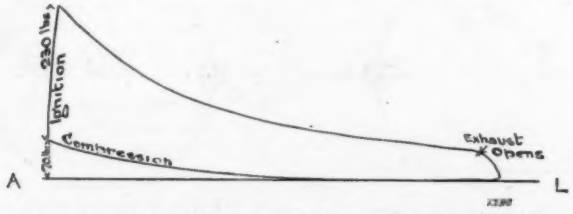


FIG. 18.—GAS ENGINE INDICATOR DIAGRAM, ENGINE RUNNING "LIGHT."

and for gas :—

$$\frac{\text{No. of cubic feet per hour}}{\text{Brake h.p.}} = \text{cubic feet per Brake h.p. per hour.}$$

During the run under full load a careful watch must again be directed to the main bearings, as they are now being thoroughly "tested." If it is found that they are heating, apply castor oil instead of the ordinary lubricating oil. If the brasses have been properly bedded, this will generally cool them.

Notice that cards from indicator must not get too straight on firing line.

Care should be taken to see that good circulation of cooling water is going on. If bottom of cylinder is cold and top very hot, circulation is bad, and causes unequal expansion and consequent straining in cylinder. From this it will be seen that a big flow of warm water is considerably better than a cold and smaller supply. The best results are got from an engine when cylinder is uniformly heated. Never take much account of results from an engine if you cannot hold your hand on cylinder jacket. Brake ropes do not require any lubricant,a little black lead sprinkled on face of fly-wheel being all that is necessary.

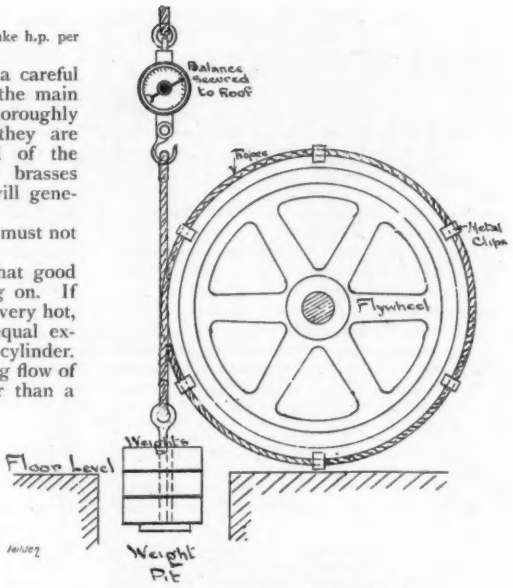


FIG. 19.—HANDY FORM OF FLYWHEEL BRAKE.

A few notes on the erection, etc., of an engine in engine-house and its care, may now be of interest :—

The first point to be observed is, that the house is of sufficient size as to allow all parts of engine to be got at conveniently.

There must never be less than from 20 to 24 in. clear space between face of flywheel and wall.

The foundation. This should always have a liberal allowance of material. A good stone foundation is, no doubt, the most satisfactory, but a very good bed can be made with concrete. Let it be a good depth, and extend well beyond sides of engine. If concrete or stone, care must be taken to see that it is firmly bedded in surrounding brickwork, etc. If this is not properly done, there is always a chance of both engine and its bed commencing to rock.

A large circulating water supply is always advantageous. Some makers allow from five to six cubic feet of water for each brake h.p. developed by engine. A large tank or tanks on the roof of engine-house and open to atmosphere is not a bad arrangement. Water pipes from engine to tanks should not have less than 4 ins. to 1 ft. rise, and join tank at surface of water. Pipes from under cylinder must draw from base of tank, or, in case of several being used, from base of last tank. A float valve and water supply should always be fitted. Water cocks require to be arranged in pipes so as to allow of water jacket in cylinder being drawn off during frosty weather, or in case any valves require to be taken off engine. In case of frost, if neither jacket water is drawn off nor gas jet left under cylinder, a cracked jacket may result from a keen night's frost.

In fixing the gas meter, arrange for it to be in one corner of engine-house. A dry meter is most satisfactory in working. The size of meter is found by $\frac{\text{B.H.P.} \times 20}{6} = \text{No.}$ of light meter required. Thus for a 30 B.H.P. engine $\frac{30 \times 20}{6} = 100$ light meter.

The gas bag, which is placed between engine and meter, must be in such a position that oil cannot be thrown on rubber discs from crank pin, etc.

If air is taken by a pipe from outside, see that end of same is protected by a perforated covering, and conducted to engine without any sharp bends.

The exhaust pipes, which are best of C.I., should be at least 25 per cent. larger in area than exhaust valve seating. They must be coupled to breaking up boxes

having at least double the cubical contents of cylinder, and from thence, if further quietness is required, to a silencer. This may consist of a C.I. box filled with loose gravel or any such material. A stand-pipe from exhaust box closed at the end, and having a number of holes drilled in sides, answers very well. The exhaust gases must never be turned into a chimney, or even into a pit.

Dangerous explosions are liable to occur where pipes are so managed.

Observe that there is not any woodwork near exhaust pipes, as the latter get very hot in working, and might, if woodwork is very near, cause fire.

One more point before leaving exhaust arrangement: See that small plugs, which should be screwed in bottom of exhaust boxes, can be got at. Water often accumulates here, and of course requires to be drawn off, or exhaust becomes choked.

A guard or fence sufficiently large to cover crank, and even end of piston when it is full stroke out, is well worth the expense of fitting, both as a protection for attendant and engine itself.

Many makers advise a friction clutch in preference to fast and loose pulley arrangement, most generally adopted. The ease and smooth working of a clutch certainly commends itself to every engineer.

There are just one or two little items which may be referred to, for the benefit of engine attendant:—

He should always try and avoid having to rush the starting of his engine.

Always notice that the burner for heating ignition-tube is clean, and burns with a proper Bunsen flame; if it is white or luminous, showing lack of air, soot will be deposited on tube, and cause bother through cylinder charge failing to ignite.

A spare ignition-tube should be handy, so that in case of failure of one in engine a fresh tube may be fitted in a few minutes.

Engines for electric lighting are generally arranged to carry two ignition-tubes, to prevent stopping through failure of tube.

Oil boxes must be kept well supplied with special oil for gas-engine use, which is now easily to be obtained.

Piston requires to be taken out occasionally and cleaned, as well as combustion space.

"Cracking off," as it is termed, which is a premature explosion taking place whilst air valve is open, is generally caused by an insufficient gas supply, which causes a flame to live in cylinder, until air and gas are again being taken, when it ignites them as they enter.

"Cracking off" may occur also from an overheated exhaust valve. When exhaust valves are not water-jacketed, this premature explosion is of frequent occurrence.

One more point in conclusion—

Gas pressures from town supplies very often vary during the day. If this variation is much, the gas supply to engine should be regulated accordingly. JAMES HALL.

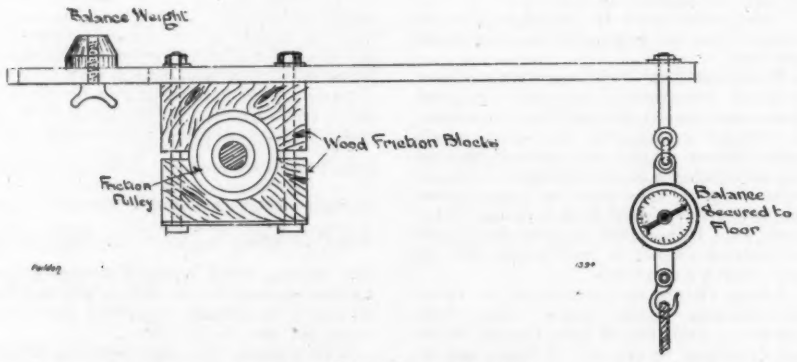


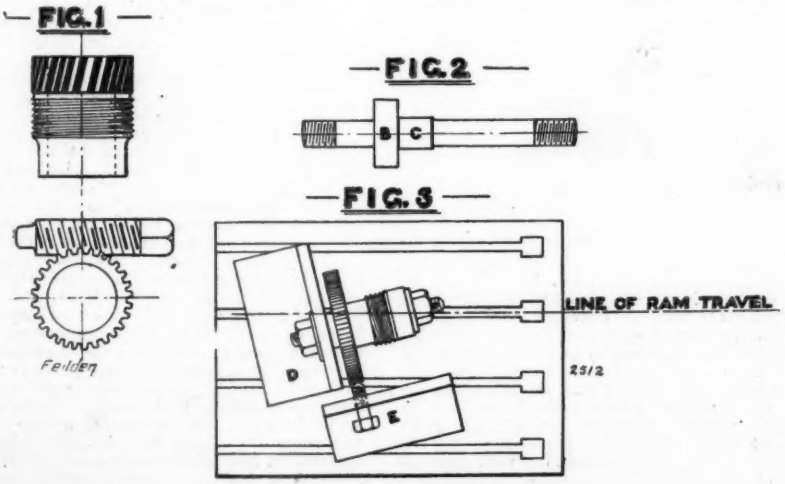
FIG. 20.—"PRONY" FLYWHEEL BRAKE.

WORKSHOP PRACTICE

The purport of this section of FEILDEN'S MAGAZINE is to give the skilled mechanic in our great industrial establishments an opportunity of bringing his practical ideas and experience into print. Inventive capacity and careful thought on the part of the workman is what we desire to encourage and foster. To this end we invite skilled mechanics, foremen, under-foremen, and heads of departments, to communicate practical suggestions, which, if accepted, will be suitably paid for. Wherever possible, drawings should accompany the contribution; rough sketches will suffice, as, when draughtsmanship is at fault, we will do all that is necessary to render them fit for publication. Nothing will be too poor for a careful inspection. Questions relating to shop practice are also invited, for which we pay one shilling. Answers to these questions that are printed are also suitably paid for according to merit.

❀ ❀ ❀

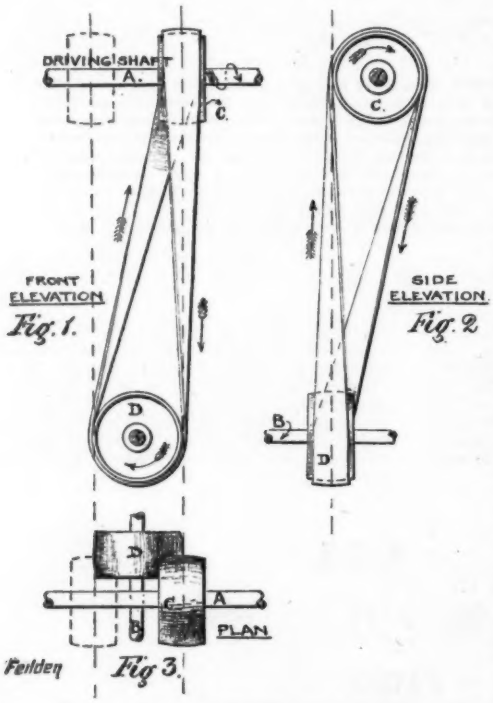
Cutting a Worm Wheel.—Having to make some packing glands, with the top edge to be finished as a worm wheel, engaging with a worm, Fig. 1, for tightening purposes, and as the time was limited, the question arose, Could we not manage to do them with the tools at our disposal? and, after some consideration, the following method was adopted:—A piece of stock, mild steel, was turned as Fig. 2, and fixed into an angle plate previously drilled and reamered, and tightened up at back by nut *D* Fig. 3. A cut change wheel off one of the lathes was fixed tightly on stud at *C* against collar *B*. The number of teeth in this being a multiple of the ones to be cut, the front portion of the stud carrying the gland, which was kept tight by washer and



METHOD OF CUTTING A WORM WHEEL.

nut as shown. A second plate, set at right angles and carrying a set screw, *E*, with a pointed end, formed the dividing arrangement, the withdrawal of which, together with the slackening of nut *D*., allowed the stud to be revolved to the correct position for the next cut. GEO. R. MARTIN.

[NOTE.—The form of the shaper tool would have to exactly coincide with the tooth space of the wheel to be cut.—ED.]



METHOD OF ARRANGING QUARTER-TWIST BELT DRIVING.

Quarter-Twist Belt Driving.—This form of driving is at times very convenient, and the reason of its not being more commonly used is probably the fact that the principles governing its successful application are not generally understood. In arranging this drive the main thing to remember is this—"When a belt connects two pulleys whose respective planes of revolution are at an angle one to the other it is necessary that the centre line of the length of the belt shall approach the pulley in the plane of the pulley's revolution, which is sufficient, irrespective of the line of motion of the belt, when receding from the pulley." This will be readily explained by the sketches, of which Fig. 1 is a front elevation, Fig. 2 a side elevation, and Fig. 3 a plan with the belt removed, so as to show more clearly the relative positions of the pulleys. If it is desired to rotate the pulley *D* in the contrary direction to that shown the dotted lines in Figs. 1 and 3 give the required position of driving pulley *C*, and in Fig. 2 the right hand portion of the belt would pass in front of the lower pulley, and not behind, as now shown. In favour of this arrangement of driving may be instanced the fact that it is the rule in modern cotton-spinning mills to drive the slubbing, intermediate, roving, and often the drawing frames, by this style of belt driving, thus saving the cost of extra belting and guide-pulleys, or else numerous countershafts and additional pulleys. C. S. B.

Machine Forging. — The ordinary methods of forging wrought-iron are met with so frequently that a reference to them would be of little interest to the majority of artisans, but as the following examples illustrate the application of machinery to the production, some useful hints may be gathered and the principles adopted for other forms of work. The "Oliver," "Ryder," and other forging machines have been of the greatest service for "swaging" purposes, and have considerably reduced the labour of the smith, whilst the steam hammer has become such a valuable auxiliary that no modern smithy would be equipped without one. Of late years drop-hammer forgings have entirely displaced anvil forgings, especially for repetition work in quantities, with the further advantages of reduced cost and greater exactitude. The first-named machine is, perhaps, the one which most readily accommodates itself to general work, and is easily arranged for various kinds of jobs. The following illustrate three distinct specimens of work produced by the "Oliver." Fig. 1 shows a "frost-stud" forging, inserted in horseshoes to give a greater purchase on the ground in slippery weather. Fig. 2, the elevation and section of cast-iron block or anvil, showing the arrangement of lever and plunger, mostly used for the purpose of ejecting a forging from the swage or die as soon as completed. The square holes on the top receive the several forms of swages, cutters, etc., while the round ones on the side permit of the adjustment of the lever operating the plunger to any position best suited to the work. At Fig. 2 the stud is shown in a vertical position on the swage, the finish to the head being given by the die, Fig. 3, which is fixed in the hammer-head

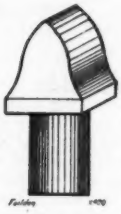


FIG. 1.
"FROST-STUD" FORGING.

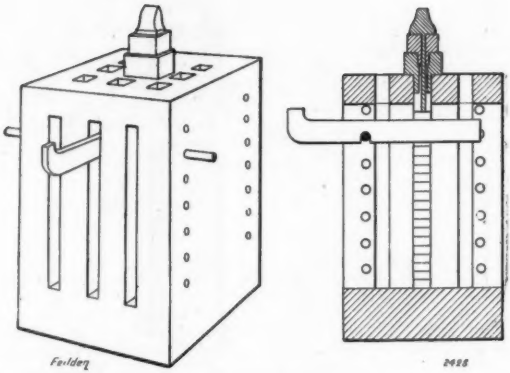


FIG. 2.—ELEVATION AND SECTION OF CAST-IRON SWAGE BLOCK.

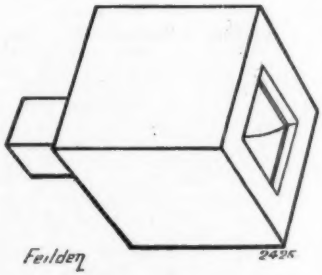


FIG. 3.—DIE FIXED IN HAMMER-HEAD.

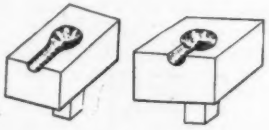


FIG. 9.—SWAGES.

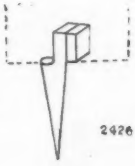


FIG. 10.—PUNCH.

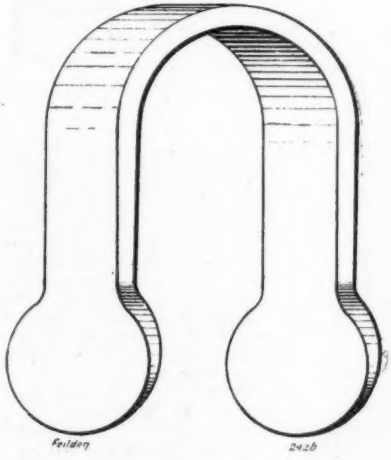


FIG. 7.—COMPLETED SHACKLE.

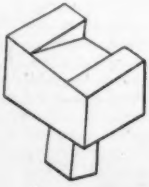


FIG. 4.
WEDGE CUTTER.

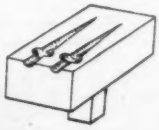


FIG. 5.
DIE FOR SWAGE BLOCK.

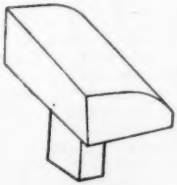


FIG. 6.

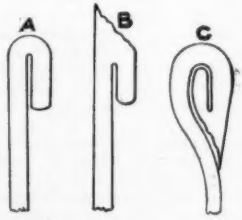
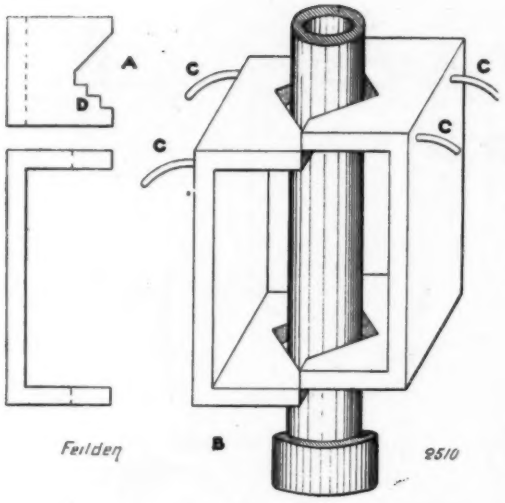


FIG. 8.
METHOD OF SHAPING FLAT IRON.



A HANDY VICE CLAMP.

of the machine. The previous operation, that of forming the shank, is made upon a great number of pieces at once in top and bottom swages, each containing a semi-circle of the required diameter, the pieces being cropped off to length by wedge cutters, Fig. 4. The next example is that of a rake-tooth of pear-shaped section formed in right- and left-hand dies, the bottom one, Fig. 5, resting in the swage-block; the top half fixed in the hammer-head, as previously described. Fig. 6 is used for the purpose of reducing the bar to a pointed or other form most suitable for entering the swages. The shackle, Fig. 7, is another example, and is made as follows. A piece of flat bar is heated and bent, as shown at *A B C*, Fig. 8, after which it is again heated and placed in the "balling tools" or swages, Fig. 9, the hole being driven through by a punch, Fig. 10, fixed in the hammer. These examples serve to illustrate the varied application of the "Oliver" machine, and as the swages and dies are generally made by the operator, the expense is considerably reduced as compared with the costly ones used in connection with drop hammers, or the more intricate forms of forging machines; therefore the writer has no hesitancy in recommending their employment as a convenient accessory and labour-saving tool.

FRED. E. THOMAS.

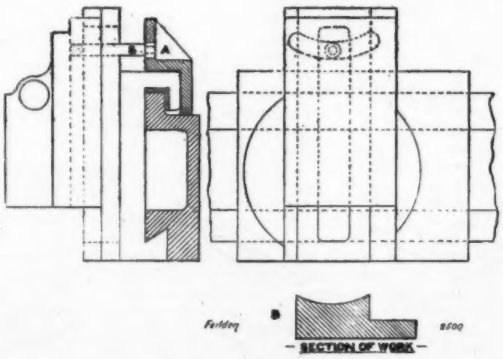
[The "Oliver" is a very old type of treadle machine worked by the operator, the "Ryder" and others being belt-driven.—ED.]

A Handy Vice Clamp.—This consists of two pieces of flat steel of suitable section, bent up at each end to a right angle, with the ends Veed as shown at *A*. It is specially adapted, as shown at *B*, for holding rods or tubes to be cut or screwed; its gripping power may be increased by toothing the edges as at *D*. Pieces of brass wire—*C C C C*—soldered or riveted on, serve to support each piece on the vice jaws.

J. C. TRUMAN.

Planing a Radius.—The planing or shaping of a radius is an operation at all times accompanied with some little trouble, as, owing to the absence of the necessary mechanism, both the vertical and horizontal feeds must in this case be manipulated by the machinist. Below is shown an arrangement which dispenses with this operation, whilst the principle may be applied to the production of other forms. A portion of cross-slide and tool box is shown, and at *B* the specimen piece of work in section, the arrangement for planing the concave portion as follows: The vertical screw of the swivel slide is taken out, and the down slide is supported by a stud, *S*, carrying at one end a bowl, which runs in a slot of the required form, cut or cast in an angle piece *A*, bolted or cramped on the cross slide. As the tool box is traversed in a lateral direction the bowl follows the form in the angle plate, thus reproducing the same contour as the *centre line* of the slot.

E. ROLLINSON.



METHOD OF PLANING A RADIUS.

INDUSTRIAL PROGRESS

ENGINEERING NOTES AND COMMERCIAL INFORMATION

FROM ALL SOURCES.

MECHANICAL ENGINEERING.

A Prosperous Engineering Firm.—To judge from reliable statistics, there are at all events some of our engineering firms that have been able to hold their own, and to occupy their place in the front rank of the world's producers, notwithstanding the remarkable progress made by our American competitors. Among these deserves to be mentioned the firm of Galloways Ltd., Manchester, who carried off the Grand Prix at the late International Exhibition at Paris, and consequently have the unique distinction of having obtained the highest award in three consecutive international exhibitions, which should go a good way in dispelling despondency regarding the future prospects of British industry. Hand-in-hand with the gaining of a new honour has gone the financial prosperity of the firm, as is evident from the report of the last annual meeting of the shareholders held in February, at which the chairman, Mr. Charles J. Galloway, announced that the gross earnings of the year amounted to £26,401, and after providing liberally for depreciation and the payment of Directors' fees, with the balance brought forward, the total standing to credit of Profit and Loss Account was £26,928. Deducting from this the interest on debenture stock, the dividends on the 5 per cent. preference shares, and half the cost of installation of the exhibits sent to Paris, there remained a disposable balance of £13,312. The Directors in respect to this recommended the payment of a dividend at the rate of 6 per cent. per annum on the ordinary shares, the transfer of £3,000 to the Special Reserve Fund, which thus is raised to £14,438, the transfer of £1,500 to the Special Depreciation Account, and the carrying forward of £574. These recommendations were unanimously approved. It was incidentally mentioned by the chairman that the important and extensive structural alterations and additions at the Knott Mill Works referred to at the previous annual meeting were now rapidly approaching completion, and promised to be a source of additional profit. There had become necessary, however, some extra expenditure for additional machinery and plant, etc., required for the manufacture of high-speed engines, and to meet this the Directors had resolved upon a further issue of 2,746 ordinary shares of £10 each, equal to one-fifth of the number of ordinary shares previously issued. All these shares were offered to and taken up by the present shareholders.

Superiority of British as compared with American Machinery.—It is pleasant to hear nowadays a good word regarding the value of British make as compared with that of our trans-atlantic cousins—not that the fact is not known by everybody that, with the exception of light machine tools and a few specialities, British manufactures excel all others as regards their solidity and intrinsic value; but it has been the fashion of late, and, oddly enough, in our own country more than elsewhere, to "boom" American machinery, so that so eccentric an act for the times as to praise British work is quite startling, but not the less welcome, for a change. We hasten therefore to inform our readers that, in a report sent to the Foreign Office by H.M. Legation in the City of Mexico, it is stated that, although the agricultural machinery and implements used in Mexico are for the time being mostly imported from the United States, the inhabitants prefer English threshing machines, and recognise their superiority, saying that their finish and adjustment are better, and the results obtained are greater; but owing to the inability to procure pieces, in case of accident, to replace such as are injured or worn out, the orders are given to American importers, since manufacturers in the United States provide for such emergencies. This is true enough, and those of our own manufacturers who are ready to go ahead with the times might take suggestions from American methods. The cylinders of the American machines are made in pieces, and the teeth are attached with screws and nuts; in case one or more of these should break they can be taken out and new ones put in instead; while in our own machines cylinder and teeth are made in one piece, which, if repairs are necessary, has to be taken out to be replaced by a new piece. If we bear in mind that the replacing of the piece requires far more time and causes much greater expense than in case of a breakdown occurring here in England, since the local foundries in Mexico will have to make a special mould before casting the piece, while several months also may elapse ere it can be procured from the British makers, and that during the interval the machine is useless, we can hardly blame the Mexican farmer for reluctantly buying American machines, even though he knows that ours are better. Still it ought not to be very difficult to remedy this drawback in British threshing machines for export, especially as, according to H.M. Consul, it seems to be well worth our

while to cater for Mexican customers, among whom, we are informed, there is a steadily increasing demand not only for agricultural but also for mining machinery and tools, cutlery, and all kinds of hardware. Our American friends, as has been usually the case in recent times, have stolen a march on us, it is true; for several transatlantic firms have established depôts in the Mexican capital, where a very large assortment of machinery and tools is kept. Nevertheless there is, as the proverb says, always room at the top, and, since our manufactures are of the highest type, we should surely get the best trade the moment we are ready to make the necessary effort and change our old-fashioned methods.

MARINE ENGINEERING.

New Steamship Line.—Heretofore, the trade of the Amazon has been in the hands of two English firms. In the future, however, their place will probably be taken by German exporters. A regular service between Hamburg and Northern Brazil is already in operation, and the steamship companies are as usual acting as pioneers of German trade in supplying direct and regular channels of communication. The first vessel of the Hamburg-American Line (the *Canadia*) left the port of Hamburg on July 14th. It touched (on the outward voyage) at Havre, Oporto and Lisbon, carrying freight from Germany of manufactures and cement and from Portugal vegetables and wine. The unloading at Mariaos was effected without difficulty, and return freight, consisting of piassava and hides, was taken on at that port, the cargo being completed at Baltimore, the *Canadia* returning after a successful voyage of seventy-six days. The action of the Hamburg Company has given much satisfaction to the merchants at Mariaos, especially those of German nationality, of whom there are at least thirty-six. The governor at Manaos expressed, in an official speech, the hope that rubber, which does not stand a long voyage, and must be sent by fast steamers, would find a new market at Hamburg. Rubber is the principal product of Northern Brazil. Since the trial trip of the *Canadia* the *Alémania*, *Valesia* and *Croatia* have been sent out in August, September, and October, and steamers for the ports of Para and Manaos are advertised to leave Hamburg on the 15th of each month. Should German merchants, as no doubt they will, fully avail themselves of the advantages thus offered, Germany's commercial and political influence in Brazil will greatly increase, and one of the future's richest markets may be eventually lost to us, for it is said that the two English companies have not used their monopoly in such a way as to win popularity.

Steam Tugs Wanted.—H.M. Consul-General at Naples reports that the new works for establishing commodious docks in that city, which were opened last year by the late lamented King Humbert, have been very briskly pushed on ever since. So large an enterprise, however, can, even in the best case, hardly be completed for some years yet. Meanwhile, however, it will be of interest to our ship-builders to learn that among the requirements absolutely necessary to the success of the undertaking is a good supply of small powerful tugs. At present such tugs are entirely absent, and the boats in use are fit only for hauling barges, but quite useless for manipulating big steamers speedily in narrow and crowded waters.

CIVIL ENGINEERING.

Harbour Works.—The "Boletin Oficial" of the Argentine Republic, in November last, published additional information and alterations referring to the projected construction of harbour works at Rosario, of which the following summary may be of interest to British engineering firms. Tenders are asked for for the building and working of a commercial port at the city of Rosario di Santa Fé. These tenders, in case of British competitors, must be handed in before June 10th this year to the Argentine Legation in London, in duplicate, or until the 11th of July this year to the Ministry of Public Works at Buenos Ayres. On the latter date, at 3 p.m., all tenders, whether presented in Buenos Ayres, in London, or in the Argentine Legations in other capitals will be opened. The conditions of tendering, together with plans and other documents, will be on view in the Ministry of Public Works in the Argentine capital, as well as in the Argentine Legations in London, Berlin, Paris and Washington, and the study of the tenders will be entrusted to a commission of ten members, who have been already appointed. A copy of the full notice as it appears in the Official Gazette of the Republic may be seen at the offices of the Commercial Intelligence Branch of the Board of Trade, 50, Parliament Street, London, S.W., any day between 10 a.m. and 5 p.m.

Steel Bridges at Low Cost.—One of the latest achievements of our transatlantic cousins is the reduction of the cost of small steel bridges to a minimum, to judge from the price of two bridges of pleasing design, built to carry roadways over a stream at Rye, U.S. The span between masonry abutments is 30 ft., and the width is 42 ft. between railings, including a 30-ft. roadway and two 6-ft. sidewalks. There are six rolled steel joists, 20 ins. deep, 32 ft. long, 6 to 7 ft. apart, connected by transverse angle iron tie-bars. Across these are laid rolled steel joists 4 ins. deep, extending the full width of the bridge and spaced 26 ins. apart. Over and around these beams a concrete floor is filled in, composed of one part Portland cement, two parts sand, and five parts of 1½-in. stone. This is shaped to form the proper crown for the roadway. For the footpaths, three lines of oak floor joists are fitted between the 4-in. steel joists, with 1-in plank floor, upon which is the concrete walk, this concrete being made with finely crushed stone. The walk is 4 ins. thick. The roadway is paved with special paving brick, grouted with

cement, and at each end of the bridge the pavement terminates with a course of stone kerbing 4 ins. thick and 16 ins. deep. The handrail is of ornamental ironwork. The bridge is designed to support a uniformly distributed load—including its own weight—of 200 lbs. per sq. ft. of surface. The total cost of each bridge, including the abutments, railing, painting, etc., was about £715.

ELECTRICAL ENGINEERING.

The Arrival of Electric Power in British Works.—The signs that the call to arms sounded by the Engineering Press in this country has not been in vain are accumulating, and everywhere a healthy activity is perceptible, showing that our manufacturers are preparing for the fray. They seem to have realised at last the expensive lesson of the Boer war, that the highest individual qualities go for little nowadays, unless our weapons are equal in efficiency to those of our antagonists, and that our first duty is to secure the most modern and most efficient equipment; for to be well equipped is in our age more than half the victory. In the industrial world, however, electrical motive-power and electrical apparatus in the workshop occupy the place that quick-firing guns, smokeless powder, and other novelties occupy in the military world, and to cling to steam-engines and belt transmission where twice the work can be accomplished by electric motors and the transmission of power by the electric current, means to sacrifice foolishly and uselessly human energy and human skill in an unequal contest. This is one of the lessons that cannot be repeated too often, and which, we are glad to see, Mr. Geipel, M.I.E.E., in a paper read by him a few weeks ago at the meeting of the Gloucester Engineering Society, endeavoured to impress upon his colleagues, well knowing though he did that he might be accused of superfluous reiteration. Even this repetition, however, of what others had said before him would have been quite justifiable if for no other reason than the paramount importance of the subject. The way in which he treated the various details of the problem was the clearest proof that in the hands of a well-informed and conscientious student of applied electricity it never loses interest, and readers of Mr. Geipel's paper, however well acquainted they may be with the essential features of electrical motive-power, will find that their time has not been wasted in perusing it. The lecturer began with a short analysis of the three chief methods of driving works without the use of electricity—namely (1) that method by which the power developed from one very large machine is transmitted by shafting to the various tools, (2) that by which a number of engines are distributed over the whole area of the works but are fed with steam from long pipes diverging from a central bank of boilers, and (3) that in which units, each consisting of an engine with boiler attached, are scattered all over the works. Describing the working of the first method, he demonstrated that the average loss of power in shafting, obtained from six cases where the machines were doing heavy work, represented 62 per cent., and in six other cases of light work 55 per cent. Referring to the second method, he showed that the loss of power in the pipes, owing to condensation, amounts to not less than the equivalent in steam of half a ton of coal per annum per square foot of uncovered pipe surface, if continually under steam and exposed to the atmosphere, while with the best lagging the equivalent is one-sixth of a ton. To this must be added the loss in the engines; and Sir T. Richardson ascertained, as the result of a test of 31 different engines in his own works, that, exclusive of losses in the steam pipes, the consumption amounts to 51 lbs. per i.h.p. per hour. This shows the enormous waste in using small and scattered engines, which are almost invariably low-pressure non-condensing engines. In modern compound or triple-expansion engines the consumption, as is well known, is not higher than from 13 lbs. to 16 lbs. of steam. Finally, as regards the third method, Mr. Geipel justly remarked that it was almost unnecessary to point out the expensiveness and inefficiency of the system. From the above figures it will be realised that Mr. Geipel had no difficulty in showing the enormous economy resulting from electrical transmission of power, not to speak of the advantages of cleanliness and comfort, the saving of space, and the convenience of manipulation.

Improvement in High Tension Distribution.—A contributor to the *Zeitschrift für Elektrotechnik* describes an arrangement by which the manipulation at a distance of the high tension switches, which are unsuitable and unsafe for private residences, can be simplified. In order to avoid the losses caused in high tension distribution by the transformers when not doing work, the primary coils of these transformers may be connected in parallel, and thrown in only when they are required to do work; but on account of the danger that may arise from leaving the manipulation of the switches to persons having no technical knowledge, the operation at a distance becomes necessary, for which a rather complicated device was recently invented by Mr. H. Müller, of Nürnberg. The simplification above referred to comprises a local battery and a solenoid switch of special construction. The lower end of the long solenoid core is near an armature with three arms. The one arm is attracted, the other plays between stops, and the third, non-magnetic, arm fits into a recess in the core, preventing its sliding down normally, but allowing it to fall when the first-mentioned arm is attracted. The upper part of the core, still below the solenoid, which energises it, is slotted, and into this slot reaches a bent lever, which, when the core sinks, closes the primary transformer circuit, so that the secondary current can circulate in the solenoid, after the local switch has been reversed. The same solenoid coil receives the local and the secondary alternating currents. In the second case the core travels up again, throws the bent lever over, and thus breaks the primary circuit.

RAILROADS.

New Railroad from Quebec to Vermont.—According to reliable information an American company, known as the Central Vermont Railroad Co., has leased for ninety-nine years an old road between Quebec and Vermont which, owing to financial difficulties, was closed to traffic between 14 and 15 years ago. Although the ties have decayed, and in many places the culverts have caved in, the road-bed is still in fair condition, and the work of reconstruction, which has begun already, will not be very difficult. This road will open up a new agricultural section of Quebec, and will, in a measure, increase the trade between this district and the United States. It extends from St. Lambert, near the end of the Victoria Bridge, opposite Montreal, *via* Chambly (this section is now built and in operation), to Freilighsburg and the Vermont line, a distance of 53 miles; from this point it extends to Sheldon Junction, a distance of 9 miles, where it connects with the Central Vermont Railroad, leading to St. Albans, a distance of 9 miles, and also with the Boston and Maine, running south to Cambridge Junction, and thence to Essex Junction and Burlington, Vermont. From Cambridge Junction, the same line runs eastward to St. Johnsbury, connecting with the direct line of the Boston and Maine, for Boston and all points south and west. The part of the road that is now being built, is from Farnham to Sheldon Junction, Vt., a distance of about 25 miles. The new enterprise, it is said, will in a measure injure the local traffic on the Canadian Pacific road from Farnham to Stanbridge, for the reason that freight will now be carried direct to places on the new road, instead of being delivered to Bedford for retransportation by teams, but competition in many cases turns out to be beneficial for both parties concerned.

Great Lakes and Hudson Bay Railway.—The long talked-of project of building a railroad from the Great Lakes in North America to Hudson Bay, a project that many considered to be absurd, owing to the fact that the line would pass almost entirely through an uninhabited wilderness and could therefore never pay, is, after all, going to be a reality, and in fact has already begun to take practical form. The line, which is to be known as Algoma Central, is being built, and, what is better, not in the ephemeral style of the Trans-Siberian line for instance, but in so thorough and solid a manner that it will be able to stand almost any strain to which it is likely ever to be subjected. Eighty-five-pound steel rails are used, and the locomotives are of enormous size, weighing 135 tons when equipped for traffic. The engines are so massive that railway companies were afraid their weight would injure the bridges, and they were delivered from Chicago to Sault Ste. Marie by the lake route on steam ferries. The beginning of the new line is at Sault Ste. Marie. Ground was broken less than ninety days ago, but already 25 miles of road are completed and in use, and the railway is pushing forward at the rate of half-a-mile a day. It is expected that it will require three years to complete the road. The capitalists who originated the scheme have made careful computations as to the traffic, and are confident that the road will be an excellent investment. Its origin is primarily due to the desire of the paper manufacturers to have means of transport for bringing the valuable supplies of pulp-wood from the far north to the Sault Mills; but it opens up as well a region that is fabulously rich in minerals and timber. The mineral wealth is said to be practically inexhaustible, consisting of mountains of iron, copper, and other valuable ores. Among other discoveries is that of a solid bed of gypsum, eight miles in length. In timber, the supplies are equally valuable. For hundreds of miles, it is claimed, the railway will run through dense forests of big trees, including birch, maple, hard elm, tamarack, spruce, balsam, poplar, and white pine. Curly birch, which now can be bought along the railway for 40 cents. a cord, commands $40 a thousand feet in the United States. Elmwood, that can be cut at 10 cents. a cord, sells for $25 a thousand feet at Minneapolis and other points in the North-West, that are within easy shipping distance. The Ontario Government is greatly interested in the opening up of this rich territory, and has aided in the construction of the railway by a big grant of land. At the end of the first fifteen miles the railway commenced to haul heavy consignments of timber, and traffic is following closely upon construction, so that the road is almost certain ultimately to yield magnificent profits.

Sizes of American Locomotives.—The last ten years have seen a remarkable increase in the size of locomotives built in the United States. At the beginning of that period the cylinders of first-class passenger locomotives were 18 ins. by 24 ins., while the area of the grate was 22 sq. ft., and that of the heating surface 1,200 sq. ft. The weight on driving wheels amounted to 29¼ tons, and the total weight to about 45 tons. The most recent types of such locomotives have only 19-in. or 20-in. cylinders, but the heating area represents from 2,200 to 3,000 sq. ft., and that of grate from 30 to 36 sq. ft.; the weight on drivers being from 45 to 60 tons in the modern ten-wheel locomotives, or, with two pairs of drivers, 45 to 54 tons. A similar increase has taken place in freight locomotives, and in those built for heavy loads and for service in mountainous districts 101¼ tons on drivers are not unusual.

MINING.

Shaft Lining.—A new use for concrete has recently been discovered in the collieries of the Cockerill Company, at Seraing, Belgium, where it has replaced the brickwork for lining in circular shafts, drifts, air-passages, etc. The concrete used for this purpose has been entirely obtained from blast furnace slags; those from forge iron, broken to 30 or 50 millimetres, being used as ballast, while the mortar is made of granulated slags, hydraulic lime, in the proportion of five to one by volume, and slag cement. These are

incorporated in a mortar mill, but no addition of water is necessary, as the granulated slag contains enough. Slag cement is made of about 75 per cent. of granulated grey iron slags and 25 per cent. of slacked lime. When the slags are tolerably uniform in character, chemical analysis of the material is not necessary, except when the furnace charges contain magnesia, which should not be present to a greater extent than 3 per cent. The materials required for a cubic mètre of concrete are 0·750 cubic mètre granulated slag and 0·150 cubic mètre hydraulic lime.

MISCELLANEOUS.

Appointment.—Major A. H. Wolley-Dod (late R.A.), until recently of the Royal Arsenal, Woolwich, has obtained an important appointment with Messrs. Hadfield's Steel Foundry Co., Ltd., Sheffield, and will represent their interests in connection with war material, including projectiles of all kinds.

Errata.—In the March issue of FEILDEN'S MAGAZINE, on page 308, in the second column, the 17th line from the top, instead of "Armsen," read "Armeen."

On page 396, in the second column, in the second paragraph entitled IRON MINES, in the seventh line from the top, instead of "250,000 tons," read "19,250,000 tons."

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ARCHITECTURE AND BUILDING.

1. Construction and Design.

Acoustics. — *Architectural Acoustics. Symphony Hall, Boston, U.S.A.* Description of the new home of the Boston Symphony Orchestra, which is said to be the first building ever erected in the United States whose acoustic properties were not during the planning and construction very largely a matter of mere guess work, and was built on the basis of data obtained during a very carefully conducted enquiry into the problem of acoustics made at Harvard University.—*Builders' Journal*, Feb. 9th, p. 10.

Chimneys.—*A 360 Foot Single Shell Chimney.* Description of the construction of the immense smoke-stack of the Metropolitan Street Railway Company's Power House, at Constable Hook, N.J., U.S.A., built of red bricks for the square portion, and of moulded bricks for the round portion. The internal diameter of the chimney is 20 ft. at the base, decreasing gradually to 10 ft. at the top.—*Engineering Record*, Jan. 26th, 1901, p. 80. (Ill.)

Concert Buildings.—*The Music Hall of the Pan-American Exposition.* This is an interesting article, giving full structural details of the above-named music-hall at Buffalo, a building 70 ft. high to the main roof, and occupying a site of 150 ft. sq., having three principal façades.—*Engineering Record*, Feb. 9th, pp. 132-137. (Ill.)

Ecclesiastical Buildings.—*The West Fronts of the English Cathedrals.* This is a paper Mr. H. H. Statham, read before the Sheffield Society of Architects and Surveyors, in which the author treats the historical aspect only in passing, and takes the architectural and critical point of view as his chief subject.—*Builder*, Feb. 23rd, 1901, pp. 182-186.

External Form of Buildings.—*Skyline.* Abstract of a paper read by Mr. Hartwell Grayson, B.A., read before the Manchester Society of Architects, dealing with the pleasing or displeasing effect of Skyline.—*Builder's Journal*, Jan. 30th, 1901, pp. 486-88. (Ill.)

Stables.—*Hints on Stables.* By a Hunting Man. The article is of considerable interest, as it emanates from a writer who frankly acknowledges that he is no architect, nor in any way connected with the profession, and whose only object is, as he adds, to promote the welfare of the horse, and to save owners of horses unnecessary expense. The criticisms and suggestions, though some will be read with amusement, are, on the whole, worthy of attention and of practical value.—*The Builder*, Feb. 16th, 1901, pp. 152-54.

2. Heating and Ventilation.

Heating. — *Low Pressure Steam Heating in France.* Extracts from a paper on the "Theory of Low Pressure Steam Heating," presented to the American Society of Heating and Ventilating Engineers, by Gustave Debesson, of Paris, France. — *Engineering Record*, Jan. 26th, 1901, pp. 87, 88. (Ill.)

—— *Low Pressure Hot Water Heating by Direct Connection with the Steam Boiler.* Abstract of a paper read before the American Society of Heating and Ventilating Engineers, by Mr. John Darnley, of Philadelphia, in which the author describes an interesting method of overcoming a difficulty which arose from making a connection too close to the water-line of a steam boiler.—*Engineering Record*, Jan. 26th, p. 86. (Ill.)

—— *Proportions in Combination of Hot Air and Hot Water Heating.* Abstract of a paper presented to the American Society of Heating and Ventilating Engineers, by Prof. R. C. Carpenter of Ithaca, New York, in which the author describes various combination systems, and the favourable or unfavourable results obtained by means of these systems. He finally comes to the conclusion, that in the combination system of hot water heating in connection with a furnace, the hot air takes up a greater proportion of heat, for a smaller consumption of coal than for a larger consumption of coal, which seems to indicate that the portions of the building served with hot air, receive more than the proper proportion during mild weather.—*Engineering Record*, Feb. 2nd, 1901, pp. 109, 110.

Ventilation and Heating.—*Ventilation or Heating of the American Exchange National Bank, New York.* Description of the ventilating and heating plant of the premises of the above-named bank, which occupies for its own use the basement and first floor of a 16-story office building recently erected by the company. This plant comprises a plenum system of forcing air into the rooms of the basement and first story, and an exhaust system for drawing the air from them by suction, into and through the sub-basement or cellar.—*Engineering Record*, Feb. 16th, 1901, pp. 158, 159. (Ill.)

3. Plumbing and Gasfitting.

Plumbing. — *Plumbing in the Astor Apartment House.* Description of the plumbing in the above-named house on Seventh Avenue, New York, which has a front of about 200 ft., a depth of about 170 ft., with an 80 × 110 ft. open court in the centre. It is eight stories high, and arranged for about 12 sets of apartments on each floor. The author of the article gives a detailed description of the pipe systems for drainage, sewerage, hot and cold water, and of both the tank and street-pressure systems. —*Engineering Record*, Feb. 2nd, pp. 112, 113. (Ill.)

4. Miscellaneous.

Artificial Stone. — *Nature Out-done in Stone Creating.* The article refers to a number of cases in which artificial stone, furnished by the Victoria Stone Company, has been very successfully used in the erection of buildings, and, both as regards colour and durability, has been shown to be more than equal to natural stone, so that the suggestion, that by aid of chemistry and machinery stone superior to natural stone will probably be manufactured within the very near future, is by no means so extravagant as it might at first glance appear.—*The Quarry*, Jan. 1901, p. 43.

—— *The Manufacture of Artificial Stone from Sand and Lime.* This is a translation from the French text of a contribution to the *Bulletin Technique de la Suisse*, describing the history and the details of manufacture of artificial stone at the Pfäffikon Works in Switzerland, containing presses, some of which turn out 15,000 blocks per day.—*The Quarry*, Feb. 1st, 1901, pp. 95-97.

Building Materials.—*Slate in North-East Cornwall.*—The author describes the slate deposits in the above-named region in which more slate is used than in any other portion of the United Kingdom, the processes of quarrying and preparing, the use of slate for rude but effective fences, for paving, for roofing, for shelters from rain placed over the doors, and finally for memorials of the departed; the graveyards for miles around the ancient Delabole quarries, being full of slate head-stones.—*Builder*, Feb. 23rd, 1901, pp. 176, 177.

Buildings in Turkey and Crete.—*Architecture in Crete and Turkey.* Abstract of a paper by Mr. D. A. Fyfe, read at a meeting of the Architectural Association, in which the author dwells on the highly interesting architectural discoveries in Crete, including the rich remains of the Mycenean period of civilization, the identification of the sites of the cities mentioned by Homer, interesting stucco ornamentation, new types, etc. He points out the absence of imposing buildings of the Roman period, and then enters upon an analysis of the specimens of mediæval and modern architecture, among which the Turkish buildings, mostly domestic, are well represented, which offers a natural transition to Turkish architecture, to which the second portion of the paper is devoted.—*Builders' Journal*, Feb. 13, 1901, pp. 31, 32.

Gates.—*The Gates of Paradise.* This is an interesting "Architectural Causerie," dealing with the competition for the gates of the Baptistery at Florence—in which Ghiberti was the winner, to whom the city owes those magnificent gates which Michael Angelo declared to be worthy of being the gates of Paradise—and with the famous dome of Brunelleschi.—*Builders' Journal*, Feb. 6th, p. 1.

Gothic Architecture.—*The Basis of Gothic Architecture.* By Mr. E. S. Prior. Abstract of a paper read before the Architectural Association, in which the author, after a short excursion into the realm of metaphysics, endeavours to answer the question, Who really were the creators of Gothic beauty? and comes to the conclusion that Gothic art is great because it is not individual but cosmic in its origin.—*Builder*, Feb. 23rd, pp. 188, 189.

Italian Architecture.—*An Architectural Craftsman's Visit to Italy.* By Prof. Chas. Gourlay, B.Sc., A.R.I.B.A. Abstract of a lecture by the author delivered before the Architectural Craftsmen's Society of the Glasgow and West of Scotland Technical College, in which the author gives an outline of the various types of architecture to be met with in Italy, and describes the most important buildings which he visited in that country.—*Builders' Journal*, Feb. 6th, 1901, p. 2. (Ill.)

CIVIL ENGINEERING.

1. Bridges.

Bridges. — *The Charlestown Bridge, Boston.* The article begins with a short historical sketch, beginning with the building of a ferry between Boston and Charlestown in 1630, passing on to the building of the first bridge in 1786, and finally gives a comprehensive account of the new structure, begun in August, 1896, and completed in August, 1900, at a cost of over 1,000,000 dols.—*Engineering Record*, Feb. 9th, 1901, pp. 122-24. (Ill.)

Suspension Bridges.—*A Novel Suspension Bridge.* By M. S. Parker, M.Am.Soc.C.E. The author describes a novel experiment in the construction of false-work for filling a deep ravine for a railway embankment on a new line of the Union Pacific Railway between Laramie and Berford, Wyo.—*Engineering Record*, Feb. 2nd, 1901, pp. 98, 99. (Ill.)

2. Canals, Rivers and Harbours.

Dams.—*Reservoir Dams.* This is an editorial article commenting on the Presidential address of Mr. James Mansergh, read before American Institute of Civil Engineeringi n so far as it related to the progress made in the design of high dams, and dwells on the fundamental principles, derived from experience, which should control the construction of the high masonry dams for important supplies of irrigation and municipal supplies.—*Engineering Record*, Feb. 9, 1901.

ELECTRICAL ENGINEERING.

1. Electro-Chemistry.

Electro-Chemistry.—*Electro-Chemistry at the Paris Exhibition* (continued). This second instalment deals mainly with Primary Batteries and Electro-chemical Apparatus—comprising the very complete exhibit of Leclanché & Co., that of the compagnie électro-chémique, the Société Anonyme, *Le Carbone*, the exhibits of Moss & Co., an apparatus devised by Moissan, and constructed, it appears, by Poulene Frères, for the production of fluorine by the electrolysis of hydrofluoric acid, which is very fully described—and finally, with a plant for the manufacture of ozone, exhibited by the Société Industrielle de l'Ozone, together with a plant for the sterilisation of drinking water, of which a diagram is given.—*Electro-Chemist and Metallurgist*, February, 1901, pp. 32, 33.

Electro-Chemistry.—*Some Recent Progress in Electro-Chemistry* (conclusion). The present instalment deals with the electrolytical manufacture of Soda, Sodium, Calcium, Carbide, and its derivatives; the author then deals with the subject of accumulators, describing as one of the most promising types of cells the Lee-Collis (Lecoll) cell, of which a diagram is given, and concludes with reference to various interesting problems of electrolysis not touched upon as yet, such as the researches of Kahlenberg regarding the deposition of metals from non-aqueous solutions; the experiments of Dr. Courant, showing that in many cases triple cyanide salts may be used for the deposition of metals and alloys; the discovery of Mr. Burgess of Wisconsin that excellent thick deposits of nickel, otherwise not attainable, may be formed by superimposing an alternating current on the direct electrolysing current, etc. —*Electro-Chemist and Metallurgist*, Feb. 1901, pp. 41-44.

Electrolysis.—*Estimation of Metals by Electrolysis.* By Charles Nathern, B.Sc. The author, after giving an outline of the history of electrolysis as applied to analysis describes the apparatus and general conditions most suitable to the determination of the metal, and deals with the electromotive force on which the question whether a certain electrolyte shall yield up its ions depends, the current which determines the rate of decomposition, and the resistance which changes considerably during the operation. —*Electro-Chemist and Metallurgist*, Feb. 1901, pp. 46, 47.

Electrolytical Process.—*The Cowper-Coles Electrolytic Process for the Manufacture of Parabolic Reflectors* Description of the plant for manufacturing reflectors by the above method, erected for the Search Light Syndicate (of America) Ltd., and of the various operations required in connection with this entirely electrolytic system.—*Electrician*, Feb. 8th, pp. 578-581. (Ill.)

Electric Batteries.—*The Various Determinations of the E. M. F. of the Clark Cell.* By Prof. Henry S. Carhart, LL.D. The author, after referring to Latimer Clark's anticipations, and stating that a good standard cell is of more importance even than a silver voltameter, devotes his contribution to the determination of the E. M. F.—*Electro-Chemist and Metallurgist*, Feb. 1901, pp. 37-39.

Organic Compounds.—*Applications of Electrolysis to Organic Compounds.* By J. T. Hewitt, M.A., D.Sc., Ph.D., Professor at the East London Technical College.

After dwelling on the great difference between the electrolytic treatment of inorganic from that of organic compounds owing to the fact that the latter are usually themselves indifferent conductors, the author deals with a few cases of the isolation of the anion, and then passes over to a description of the indirect methods depending on the reduction or oxidation of an organic compound in a cathode or anode cell respectively, and to some processes of an even more indirect nature, such as, for instance, are used for purifying certain substances, such as sugar juice, with the aid of the current.—*Electro-Chemist and Metallurgist*, Feb. 1901, pp. 34, 35. (To be continued.)

2. Electric Lighting.

Electric Lighting.—*Electric Lighting Apparatus for Railway Trains, System Dick, constructed in the Accumulator Works of Messrs. Wüste & Rupprecht, Baden and Vienna, intended for Lighting Single Wagons.* By Emil Dick. The inventor of the system which consists in using for the lighting of a complete train the current furnished by a dynamo driven by means of a rack-wheel, which transmits the rotation of the axle, describes a modification of the arrangement by which each wagon is supplied with its own complete set of apparatus, and is thus rendered independent from the machinery supplying the train to which such a wagon may be attached.—*Zeitschrift für Elektrotechnik*, Feb. 17th, pp. 78-80. (Ill.)

3. Power.

Electric Cranes.—*The Paris Exhibition, XV.* This instalment of the description of electric exhibits to be seen in Paris last year, is almost entirely devoted to a description of the huge travelling crane, the largest piece of machinery in the Electricity Palace, which had served for the erection of machinery in the foreign section, and was constructed by Messrs. Carl Flohr, of Berlin, who had no easy task, since, as the height of the beams had to be considerable, provision had to be made against the crane tipping over when it stopped while carrying a heavy load at a great elevation, and as, in view of the large span also, enormously varying stresses had to be provided for.—*Electrician*, Feb. 1st, 1901, pp. 537, 538. (Ill.)

Continuous Current Generators.—*Continuous Current Apparatus of the Union Electricity Company, Vienna (Vereinigte Elektricitäts Aktiengeilschaft) at the Paris Exhibition*, 1900. Among the continuous apparatus described, a prominent place is given to an annealing machine patented by Kodolitsch, which is novel and original in construction; and a short reference is made to some motors designed for operating lifts. *Zeitschrift für Elektrotechnik*, Jan. 6th, 1901. (Ill.) (To be continued.)

—— *Continuous Current Apparatus of the Union Electricity Company, Vienna, at the Paris Exhibition in* 1900. (Conclusion.) The concluding portion refers to a small motor of the company's type Z, for driving of printing presses, the smallest of the company's motors of type M9, which comprises multipolar motors running at high velocity from 16 kn. upwards. This article is followed by one describing the company's *alternating current apparatus*. *Zeitschrift für Elektrotechnik*, Jan. 13th, pp. 21-25. (Ill.)

Motors.—*B.T.H. Motors.* Digest of two pamphlets recently issued by the British Thomson-Houston Company describing some new types of motors that they are now putting upon the market. The first of these deals with their C.E. type of slow- and moderate-speed motors, ranging from 2 h.p. to 10 h.p. for slow speeds and from 3 h.p. to 15 h.p. for moderate speeds. The second pamphlet deals with induction motors made for two-phase and three-phase currents and for frequencies of 25, 46, and 60 alternations per second.—*Electrician*, Jan. 25th, 1901, pp. 501-503. (Ill.)

High-Tension Currents.—*Review of* 1900. *Field of High-Tension Electricity.* The article gives a short review of last year's progress in the construction of generators, in the building of steam turbines and gas engines, refers to the transmission of currents at 40,000 volts in the United States, and the gradual adoption of high-tension systems also in Europe, to arc-light and Nernst's lamp, the gradual growth of electric tramway systems, the projects for using electricity on railways, etc. (To be continued.)—*Zeitschrift für Elektrotechnik*, Jan. 6th, pp. 1-3.

Transmission Plant.—*A Power Transmission Plant in Sumatra.* Description of a very interesting water-driven three-phase power transmission plant erected by Messrs. Siemens & Halske for the Redjang-Lebong gold-mine of Sumatra.—*Electrician*, Feb. 8th, 1901, pp. 573-578. (Ill.)

4. Telegraphy.

Aluminium.—*Aluminium as an Electrical Conductor.* Digest of a paper, by Mr. John B. C. Kershaw, read before a recent meeting of the Institution of Electrical Engineers. After making a short reference to the world's production and the price of the metal, he compares the relative costs of bare copper and aluminium for electrical purposes. He then gives a concise account of some 15 or 20 electric installations in the United States and in England which employ aluminium conductors, and then devotes the remainder of his discourse to the question of durability of aluminium, giving the result of experiments made by himself in order to follow up those made by M. Ditte, which were published in the *Comptes Rendus* of March-April, 1899.—*Electro-Chemist and Metallurgist*, Feb. 1901, pp. 36, 37.

Cables.—*Machinery for Covering Electric Cables with Lead.* Description of an improved type of lead cable press, designed by Mr. Alexander Wylie, of Johnstone, which performs all the necessary functions connected with the covering of cables with a lead tube, and is now in use in all the important cable factories of the country, which obtain their supply from Messrs. John Wilson & Son, of Johnstone, who manufacture these presses under Mr. Wylie's personal supervision.—*Electrician*, Jan. 25th, 1901, pp. 518, 519. (Ill.)

Telegraphy and Telephony.—*A Review of* 1900.—*Telegraphy and Telephony.* The article refers to Crehor and Squier's Synchronographs for cabling, to Pupins's device for increasing the velocity of cable-messages without causing loss of clearness, the Pollak-Virag system, Shafer's Coherer, Poulsen's Telephonograph, etc.—*Zeitschrift für Elektrotechnik*, Feb. 13th, 1901, p. 17.

Wireless Telegraphy.—*A Tuning System for Wireless Telegraphy.* By Anders Bull. The author describes a system invented by him one-and-half years ago, of which he gave details at a meeting of the "Elektro-technischer Verein" at Berlin, on Dec. 18th last. He claims that by means of this system the possibilty of messages being intercepted by stations for which they were not intended will be almost precluded, and independent signalling may be carried out between a considerable number of stations lying within the sphere of influence of each other's waves.—*The Electrician*, Feb. 8th, 1901, pp. 573, 574.

5. Miscellaneous.

Alternating Currents.—*On a Method of Measuring Power in Alternating Current Circuits.* By Albert Campbell, B.A. Abstract of a paper read by the author before the Physical Society, in which he points out that the three volt-meter method, though convenient and accurate when used with discrimination is sometimes liable to serious error, since in the usual way of carrying it out, the auxiliary non-inductive resistance has to be so large as to take a considerable fraction of the total available voltage, which is liable to alter the conditions of the circuit to be tested. He then describes a method of his own, in which this difficulty is entirely got rid of, for the volts lost in the auxiliary resistance need not be more than one per cent. of the total available voltage.—*Electrician*, Jan. 25th, p. 513.

Electrical Engineering Education.—*Electrical Engineering at McGill University, Montreal.* Description of a very interesting electrical equipment for teaching, being of the most improved kind, and quite up-to-date, thus differing from the gradually accumulated plant in other colleges, the funds having been supplied by Sir Wm. McDonald.—*Electrician*, Feb. 1st, 1901, pp. 541-544.

Electricity Supply Works.—*The Fulham Electricity Supply Works.* Description of the combined refuse destructor and electricity supply works of the Fulham

Borough Council, erected at an outlay of over £100,000, and opened a fortnight ago.—*Electrician*, Feb. 15, 1901, pp. 612-620. (Ill.)

Electric Units.—*Electro-chemical Units.* Summary of a proposal, brought by Dr. Le Blanc, representing the German Electro-chemical Society before the notice of the recent chemical congress at the Paris Exhibition, with the object of recommending the adoption of certain fundamental electro-chemical units.—*Electro-Chemist and Metallurgist*, Feb. 1901, p. 35.

Help in Accidents.—*First Help in case of Accidents caused by Electricity.* This is a lecture delivered at the meeting of the Electro-technical Society, Vienna, by Dr. Charas, in which this distinguished physician describes the treatment of persons injured through electricity, and the first aid to be rendered while awaiting the arrival of a doctor.—*Zeitschrift für Elektrotechnik*, Jan. 6th, 1901, pp. 9-16. (Ill.)

MARINE ENGINEERING.

1. Merchant Vessels.

Steamers.—*Steamship "Grecian," of the Boston and Philadelphia st. Co.'s Fleet.* Description of a typical American coast liner steamship, being a steel vessel built to carry about 2,500 dead weight, and 100 passengers at the rate of 15½ knots, in the coast trade between Philadelphia and Boston.—*Marine Engineering*, Feb. 1901, pp. 69-74. (Ill.)

2. Pleasure Craft.

Yachts.—*Hamburg-American Twin Screw Cruising Yacht "Prinzessin Victoria Luise."* Description of a yacht with clipper bow, being overhung at the stern, two pole masts, and two funnels, set rakishly with bell-mouth tops. Length, 450 ft.; beam, 47 ft.; and depth 30 ft.—*Marine Engineering*, Feb. 1901, p. 41. (Ill.)

3. Equipment and Machinery.

Anti-Collision Devices.—*The Anti-Collision Patent Telegraph Alarm.* Description of an alarm consisting of a bell, electric battery, and the necessary connections so fitted that whenever an order is given, such as "go-ahead," or "astern," or "stop," the alarm bell continues to ring until the order is correctly executed. The makers are Messrs. A. Robinson & Co., Liverpool.—*Engineers' Gazette*, Jan. 1901, p. 11. (Ill.)

4. Miscellaneous.

Dredgers.—*The Twin-Screw Dredger "Samson."* Description of a dredger built according to the patented design of Mr. Lindon W. Bates, of London, by Messrs. Armstrong, Whitworth & Co., Ltd., at their Walker shipbuilding yard, for the Queensland Government. At the speed trial on December 6th, four runs were made on the measured mile, during which the propelling engines were opened out to their full extent, when a mean speed of 10 knots per hour was obtained. The trial being in every way satisfactory, the vessel left the following day for Brisbane, Queensland.—*Engineers' Gazette*, Jan. 1901, p. 18. (Ill.)

Ship Ventilation.—*The Ventilation and Heating of Ships by a Forced Circulation of Warm Air.* Abstract of a paper by Mr. F. W. Jennings, read before the North-East Coast Institution of Engineers and Shipbuilders in Newcastle-on-Tyne.—*Engineers' Gazette*, Jan. 1901, pp. 19, 20. (Ill.)

MUNICIPAL ENGINEERING.

1. Gas Supply.

Gas Lighting.—*Incandescent Gas Lamps.* Abstract of a paper by Herr G. Himmel, of Tübingen, read at the meeting of the Gas Association of Bavaria, in which the author points out that the high illuminating powers given in advertisements, though quite correct under laboratory conditions, are not realised on the street, owing to dust, wool fibres and the like, caught in the gauze. He then proceeds to describe a device for obviating these drawbacks.—*Gas World*, Jan. 26th, 1901, pp. 126, 127.

Lighting Plant.—*The Robert A. Waller Municipal Lighting Plant.* A paper, by Edward B. Ellicott, M.W.S.E., read at the meeting of the Western Society of Engineers, U.S.A., on Dec. 5th, 1900, in which the author describes an interesting lighting plant, named in memory of the late Comptroller Waller, of Chicago.—*Journal of the Western Society of Engineers*, pp. 566-69.

Gas Supply.—*Carburetted Water Gas.* Abstract of a paper by Mr. W. Baxendale, of Chorley, in which the author, after having described the manufacture of carburetted water gas, dwells on some of the numerous advantages of its use, among them the economy of space used for its production, the moderate cost of plant, etc.—*Gas World*, Jan. 26th, pp. 123, 124.

2. Sewerage.

Sewage.—*Bacterial Treatment of London Sewage and American Sewage Disposal Problems.* Digest of the Third Report on Bacterial Treatment of Crude Sewage, by Dr. Clowes and Dr. Houston, presented to the London County Council, and comments on its contents.—*Engineering News*, Jan. 24th, 1901, pp. 65, 66.

—— *Recent Progress in Sewage Purification.* A paper on the subject by Arthur N. Talbot, M.W.S.E., read before the Western Society of Engineers, U.S.A., on Dec. 5th, 1900, in which the author, without giving a full description of novel features and processes of sewage purification, discusses in a general way, and without going into technical details and principles, some of the recent progress in this line, giving an outline of the latest methods and the results obtained.—*Journal of the Western Society of Engineers*, Dec. 1900, pp. 543-65.

—— *The Treatment of London Sewage.* By Prof. Frank Clowes, D.Sc. Abstract of a paper recently read before the Society of Arts, in which the author, after demonstrating the importance of the subject, draws attention to the risks of foulness from present treatment, to the steps taken by the municipal authorities, and the advantages of the bacterial treatment, and draws general conclusions from the experimental bacterial treatment of raw sewage at the London outfalls.—*Contract Journal*, Dec. 26th, pp. 1223-25.

Sewer Construction.—*The Brooks Clegg Patent Inwert Sewer Block.* Description of a sewer block specially designed and adapted for the construction of culverts, sewers, wells, tanks, water-ways, etc., manufactured by the Leeds Fireclay Company, Ltd.—*Contract Journal*, Dec. 26th, 1900, p. 1221.

Sewage Disposal.—*Results obtained with Large Experimental Septic Sewage Tanks and Rapid Filtration at Woonsocket, R.I.*, By Geo. A. Carpenter, City Engineer of Pawtucket, Rhode Island, U.S.A., read before the League of American Municipalities at Charleston, S.C., Dec. 12th, 1900.—*Engineering News*, Dec. 20th, 1900, pp. 435-36.

3. Streets and Pavements.

Paving.—*Haskinized Wood Paving.* Description of a method of treating soft wood to be used for pavements, patented by the Haskin Wood Vulcanizing Company, Ltd., 2, Dean's Yard, Westminster, London, S.W., which is said not only to prevent decay, but to harden the wood, and to be applicable without causing offensive smells such as are caused by creosoted wood.—*Public Health Engineer*, Jan. 26th, 1901, p. 71. (Ill.)

4. Water Supply.

Water Supply.—*A 24-in. Vitrified Water Conduit at Hartford, Conn.* Description of the work of laying a 24-in. vitrified pipe of a length of 16,700 ft. to lead the water from the collecting to the distributing reservoir, to replace the open canal formerly in use. The data are taken from a paper read by Mr. Wm. E. Johnson, Engineer of the Hartford Water Board, before the Connecticut Civil Engineers' and Surveyors' Association.—*Engineering News*, Jan. 17th, pp. 46, 47.

—— *Notes on Designing and Constructing Slow Sand Filters*, I. By James H. Fuertes, M.Am.Soc.C.E. This first instalment deals with the number of filter-beds required, and the size of each necessary to filter a given water-supply, etc.—*Engineering Record*, Jan. 26th, 1901, pp. 79, 80.

Water Supply.—*The Protection of Underground Water Supplies.* By William Mathews, M.I.C.E. The author deals in a general way with the question, and quotes numerous examples in testimony of the necessity of protecting underground water supplies more fully than is the case at present.—*The Surveyor*, Dec. 14th, 1900, pp. 679, 680.

—— *Waste Water Preventer.* Description of an apparatus, designed by Messrs. Ham, Baker & Co., to prevent the waste of water by consumers. The problem of restricting consumption to definite maximum seems to be satisfactorily solved, but there remains the question of securing a continuous flow in case of fire.—*Contract Journal*, Jan. 16th, 1901, pp. 108, 109.

5. Miscellaneous.

Abattoir.—*Abattoir and Cattle Market of La Villette, Paris.* Description of the Marché de la Villette, one of the largest markets in Europe, and the Abattoir, giving the essential data and a summary of the police regulations, administrative regulations, etc.—*Ice and Cold Storage*, Jan. 1901, pp. 7-11.

Municipal Engineering.—*Municipality of Paris.* Translation of the essential portion of a report recently published by the authorities of the Department of the Seine on the administration of public streets, waterworks, and sewage, with special reference to the engineering features.—*Contract Journal*, Jan. 2nd, 1901, pp. 10-12; Jan. 9th, 1901, pp. 59, 62; Jan. 16th, 1901, pp. 106-108; Jan. 23, 1901, p. 158. (To be continued.)

NAVAL AND MILITARY ENGINEERING.

1. War Vessels.

Battleships.—*German Battleship "Wittelsback."* The article points out that Germany, even more than other countries, is convinced that battleship fleets ought to be homogeneous, for she repeats a great number of defects of the *Kaiser Friedrich III.*, the standard ship, in its more recent imitations. The author then enters into a description of the *Wittelsback*, showing that, notwithstanding notable improvements, many minor defects are even there repeated.—*Engineer*, Dec. 28th, 1900, p. 646. (Ill.)

—— *Russian First-Class Battleships—Borodine Class.* The author, after referring to the tendency prevailing at present among the various nations to establish a special type for their battleships, analyses the standard lately adopted by Russia, which appears to be a normal development of a French type, which the French themselves have discarded for a more British type. The British design, with the space between the guns and the water-line heavy armoured, has permeated every navy at present. Oddly enough it came originally from Russia, which was the first country to adequately protect her lower decks; at present Russia alone has abandoned the idea in favour of a different system.—*Engineer*, Nov. 30th, 1900, p. 542.

Warships.—*Warship Construction in* 1900. This is a comprehensive review of the work done during the period named, in which, appearances notwithstanding, there has been considerable progress. The staff having been maintained at over 26,500, the full vote of 24 millions for labour, and 4 millions sterling for material will be more than earned, an experience which, as the author says, is not at present common to private naval work.—*Engineering*, Dec. 21st, 1900, pp. 807, 808, and Dec. 28th, pp. 838, 839.

2. Equipment.

3. Armour Plates, Guns and Ammunition.

Armour Plates.—*Armour Plates at the Paris Exhibition.* By M. Bailé, Paris. The article deals with the exhibits of all the French steel works manufacturing armour plates, and of four foreign exhibitors.—*Engineering*, Jan. 18th, 1901, pp. 66-68. (To be continued.)

4. Miscellaneous.

Marine Engineering.—*Interchangeability in Marine Work.* Abstract of a paper by W. D. Forbes, recently presented to the Society of Naval Architects and Marine Engineers, United States, in which the author, after pointing out what the United States has done in promoting the use of interchangeable parts in machine construction and engine work, urges the enlargement and extension of the system to embrace complete units instead of the minor parts only as now practised.—*American Machinist*, Jan. 26th, 1901, p. 38.

Military Transport.—*Allen's Military Wagon.* Description of a transport wagon devised by Colonel Charles Allen, of Sheffield, built of wood and mounted on springs and four wheels, the hind pair being 4 ft., and the fore pair being 3 ft. 4 ins. in diameter.—*Engineering*, Dec. 14th, 1900, p. 768. (Ill.)

RAILWAY WORK.

1. Motive Power and Equipment.

Locomotives.—*Brooks' Locomotive for Burlington, Cedar Rapids, and Northern Railroad.* Description of a handsome engine which the Brooks' Locomotive Works call the "Chatauqua" type, built for the above-named railway, and intended for fast passenger service.—*Railway and Locomotive Engineering*, Jan. 1901, p. 1.

Locomotive Boxes.—*Hot Driving Boxes.* Abstract of a paper by Mr. M. E. Wells, General Foreman of the Burlington and Missouri River Ry., read before the Western Railway Club, U.S.A., in which the author advocates a cast-steel driving-box on phosphor-bronze brass. The brass should be pressed in at from five to six tons pressure, and should be plugged with two brass plugs from the top of the box, or on each side.—*Railroad Gazette*, Jan. 25th, 1901, p. 57.

Railway Cars.—*The L. M. Slack Steel Cars.* Description of cars built by the Cambria Steel Company, which have many novel and interesting features. Of special interest are two types of gondola cars, which are described in detail.—*Railroad Gazette*, Jan. 18th, 1901, pp. 36-38. (Ill.)

—— *The Design of Structural Steel Cars.* By George J. King, of the American Car and Foundry Company. The author quotes a number of standard specifications for steel freight cars and freight cars with metal under-frames, covering the design of freight-car equipment of these types.—*Railroad Gazette*, Jan. 4th, 1901, pp. 4, 5. (Ill.)

2. New Projects and Lines in Construction.

3. Permanent Way and Fixtures.

Block Signals.—*Automatic Block Signals on the Fort Wayne.* Description of automatic signals, worked by electric motors, recently adopted on the Fort Wayne road on all the tracks from Alleghany to Homewood, 34 miles—24 miles of four-track line, and 10 miles of double-track. The signals differ from all similar devices heretofore used in that there is but one signal for each track—on the entrance of each block section—while yet the distant signal indication is provided for the same as in automatic systems, where two signals, a home and a distant, are used.—*Railroad Gazette*, Jan. 18th, 1901, pp. 41-43. (Ill.)

Railroad Ties.—*Preservation of Railroad Ties.* Extracts from the discussion on a paper by Mr. Chanute, read before the American Society of Civil Engineers.—*Railroad Gazette*, Jan. 4th, 1901, p. 7.

Rails.—*Renewing Old Steel Rails.* Description of a comparatively modern method of utilising worn-out steel rails which, since its introduction about four years ago, has found wide application, and has gradually developed into a very practical device; it was originated by the McKenna Steel Working Company at Joliet, Ill., U.S.A.—*Railway Age*, Jan. 18th, 1901, pp. 50-57. (Ill.)

Stations.—*Notable Railway Stations: Queen Street (High- and Low-Level), Glasgow.* Description of an interesting railway station, which is distinguished, among other features, by the peculiarity that no locomotive brings

the train within its precincts, since all trains, when yet a mile and a half distant from it, receives a last push from the locomotive, that has been moved to a place in the rear, and the train runs down an incline by gravitation, being brought to a full-stop by powerful brakes.—*Railway Magazine*, Feb. 1901, pp. 145-154. (Ill.)

4. Miscellaneous.

Asiatic Railroads.—*Railroading in Japan.* Description of the modern railways in Japan, which, although not so many years since the jinriksha was the only public vehicle in that country, are in many regards so excellent as favourably to compare with European or American railroads.—*Railway and Locomotive Engineering*, Jan. 1901, pp. 32-34. (Ill.)

Continental Railways.—*The Royal Wuertemberg State Railway.* Description of the above-named railway as a typical example of a state-managed line, having a mileage open for traffic of 1,709·25 km., of which 1,574·56 km. are main-lines and 134·69 branch-lines.—*Railway Magazine*, Feb. 1901, pp. 164-170. (Ill.)

Railway Accidents.—*The Tay Bridge Disaster.* By Nimrod. Sketch of the terrible accident which occurred on Dec. 28th, twenty-one years ago.—*Railway Magazine*, Jan. 1901, pp. 37-43. (Ill.)

Famous Railways.—*Railroad Travelling in British Columbia.* Description of that highly-interesting section of the Canadian-Pacific Railway which passes through British Columbia, and across the Rocky Mountains and the magnificent Selkirk Range.—*Railway Magazine*, Jan. 1901, pp. 44-43. (Ill.)

Railways.—*Exhibits of the Midi Railway Company at Paris.* The article deals with the interesting exhibits of the above-named Railway Company, which, though not one of the greatest French lines, is of considerable importance.—*Engineering*, Dec. 14, 1900, pp. 755-57. (Ill.)

Railway Lines.—*The Londonderry Railway.* Description of the line of railway from Sunderland to Seaham Harbour, which for nearly 50 years was the private property of the Marquis of Londonderry, and became amalgamated with the North-Eastern Railway on October 6th, 1900.—*Railway Magazine*, Jan. 1901, pp. 70-75. (Ill.)

Railway Shops.—*New Shops of the Wisconsin Central at Fond du Lac.* Detailed description of the above-named shops, which are now practically completed, and are a typical modern plant, with all the latest improvements.—*Railway and Engineering Review*, Jan. 10th, 1901, pp. 30, 31. (Ill.)

STREET AND ELECTRIC RAILWAYS.

1. Trolley Lines.

Electric Railways.—*The South Side Overhead Electric Railway of Chicago.* Description of the above line which, since electricity has been introduced in it, has attracted considerable attention, owing to the fact that a new system of wiring the cars has been adopted, whereby each car is operated as a separate unit. The inventor of this system, known as the multiple unit system, is Mr. Frank J. Sprague, of the Sprague Electrical Company.—*Tramway and Railway World*, Jan. 10th, 1901, pp. 1-8. (Ill.)

—— *The Power House and Sub-station Buildings of the Manhattan Railway Company.* The author, who is the chief engineer of the Manhattan Railway Company, describes the construction of the central station and the seven sub-stations; the central station is situated on top of a rock, and has five chimneys; each of the stacks is 17 ft. inside diameter, and 278 ft. high above the basement floor; and they are the largest of their kind in the United States, and probably in the world. They were begun on July 1st last year, and finished December 15th. The base for a height of 73 ft. is octagonal in shape, 26 ft. 6 ins. between parallel sides, with walls 5 ft. thick, built of hard-burned brick. The author also describes the condensing tunnels and the screen-chamber, the foundations for the engines, etc.—*Street Railway Journal*, Jan. 1901, pp. 1-10. (Ill.)

Electric Railways.—*The Steam Plant and Third Rail Equipment of the Manhattan Railway.* The author, who is the superintendent and chief engineer of the New York Elevated Railways, describes the steam generators de signed to furnish a maximum of 100,000 h.p. and being about to be installed. The company carries annually about 200 million passengers, a figure that will be exceeded after the new equipment is completed, the power station equipment, the track system, the engines, etc., and all the accessories.—*Street Railway Journal*, Jan. 1901, pp. 10-21. (Ill.)

—— *The Electric Power Plant of the Manhattan Railway Company: From the Generators to the Third Rail.* The author, who is the consulting engineer of the Manhattan Company, sets forth those points that may be considered novelties in the system: the potential delivered by the dynamos to the circuits which distribute energy to sub-stations is 11,000 volts, instead of 6,600 volts, as in the case of similar systems, which makes it possible to reduce the weight of the copper in the conductors by 40 per cent.; improvements in the switching devices; the maintenance of uniformity and symmetry in the organisation and arrangement of the apparatus; the design of the engine-dynamo unit which eliminates the usual fly-wheel. The construction of the revolving part of the dynamos is such as to secure very unusual strength; the angular velocity of the revolving field is uniform to an extraordinary degree. The author then proceeds to describe the electrical plant in detail.—*Street Railway Journal*, Jan. 1901, pp. 21-50. (Ill.)

2. Surface Contact Lines.

Surface Contact Lines.—*The Schuckert Contact System.* Description of this contact system, which the above-named company intends introducing also in British urban lines, as it exists on the Continent, *i.e.* in Munich, where it has been in operation since it was laid down in 1899.—*Tramway and Railway World*, Jan. 10, 1901, pp. 12-17. (Ill.)

3. Miscellaneous.

Electric Locomotives.—*On the Supersession of the Steam by the Electric Locomotive.* By W. Langdon. Reproduction of his well-known paper, read at the Institution of Electric Engineers.—*Tramway and Railways World*, Jan. 10th, 1901, pp. 38-73.

Electric Railways.—*Illustrated Interviews. No. 38.—Mr. Stephen Butler Cottrell.* The interview contains an interesting description of the Liverpool Overhead Railway, the first overhead electric railway, of which Mr. Cottrell is the manager and engineer.—*Railway Magazine*, Feb. 1901, pp. 97-112. (Ill.)

—— *The Electric Railway of the Future—A Prophecy.* By Louis Bell, Ph.D. The author is of opinion that the automotors will probably produce great revolutions, though it is possible that their effect will not be greater than that of the coming into use of the bicycle, which at one time appeared to be disastrous to the tramway companies. He also assumes that elevated railways and trolley lines will decrease in number, especially in the larger towns, and that the average speed of travelling will be considerably increased in the future.—*Street Railway Journal*, Jan. 1901, pp. 55-58.

Electric Tramway Equipments.—*Brush Tramway Equipments.* Description of the Brush standard motor for lines of 3 ft. 6 in. gauge, known as the 1,000 type, and made with four different windings, to give 17 h.p., 25 h.p., 30 h.p., and 35 h.p., at the Company's standard rating.—*Tramway and Railway World*, Jan. 10th, 1901, pp. 18, 19. (Ill.)

Electric Traction.—*A Résumé of the Electric Street Railway.* By O. T. Crosby. The author indulges in some statistical calculations, from which he derives the conclusion that at present the inhabitants of the United States save 792,000 hours per day in travelling, as compared with the period before electric traction had been introduced, and according to the adage that time is money, he concludes that the amount of time saved represents a saving of about 200,000 dols. daily. To this he adds some reminiscences of the earlier days of electrical engineering.—*Street Railway Journal*, Jan. 1901, pp. 50-54. (Ill.)

TRADE AND ECONOMICS.

1. Commerce and Trade.

Coal Trade.—*The Lancashire Coal Trade in* 1900. By T. B. Wood, Royal Exchange, Manchester. The article deals with the period of excitement through which the house-fire coal trade has been passing, owing to the scarcity of supplies; the almost unprecedented position of other descriptions of fuel—*i.e.* those required for iron-making, steam, and general manufacturing purposes, the prices which consumers had to pay being generally 100 per cent. higher than of a year or two back; the large demand for coke, and all the other abnormal conditions of the trade last year.—*Iron and Coal Trades' Review*, Dec. 28th, 1900, p. 1336.

Colonial Trade.—*Australia as a Field for Business. III. South Australia.* This is an article giving a concise description of the geographical features, the imports, and the exports of this the second of the Australian Colonies.—*Commercial Intelligence*, Dec. 8th, 1900, p. 9.

Commercial Development.—*Our Exports.* The article contains a short summary of the highly-interesting statistics collected and classified by Mr. O. P. Austin, Chief of the Treasury Bureau of the United States, referring to the world's commerce for a term of years, in which forty-seven nations are dealt with, the records being given as far back as they have been kept. The summary deals mainly with a comparison between the development of the United States and that of Germany. —*Manufacturer*, Dec. 15th, 1900, pp. 21, 22.

Competition. — *Openings in England.* In this article, published by the paper below named, attention is drawn to the great demand for electrical and other kinds of machinery existing at this moment in Great Britain, and a complete list is given of new projects, in which American manufacturers have an excellent chance of participating. Names and addresses of English engineers in charge of the various enterprises are mentioned, and the article shows plainly how wide-awake are our Transatlantic cousins in keeping a watchful eye upon all opportunities for extending their exports. — *Manufacturer*, Dec. 15th, 1900, p. 31.

Iron and Steel Trade.—*Some Controlling Features of the Iron and Steel Trade in* 1900. The article analyses the remarkable situation of these trades last year, and inquires into its causes, going back for this purpose to the year 1895, since which time—*i.e.* within four years—the total make of pig iron in the leading countries of the world advanced from 25,000,000 tons, in round figures, to 35,000,000 tons.—*Iron and Coal Trades' Review*, Dec. 28th, 1900, pp. 1235-36.

—— *Iron and Steel in* 1900. Summary of the production during the year and analysis of that period, the beginning of which continued the active and prosperous condition of the metals which prevailed at the close of 1899. The boom reached its maximum in the first half of 1900, and was followed by a reaction, beginning in the United States and gradually extending to Europe. Towards the closing of the year a recovery began in the United States, leaving the outlook for the future at the end favourable for the United States, but having no similar effect in Europe. — *Engineering and Mining Journal.*

Trade Review.—*Trade of the World.* This is an interesting announcement of a projected publication by the Bureau of Statistics of the United States Treasury Department, of which the opening chapter has already appeared, and which is to contain in one volume a complete picture of the world's commerce.—*Manufacturer*, Dec. 15th, 1900, p. 26.

Turkey and Foreign Trade.—*How Turkey harasses Foreign Trade.* Comments on the arbitrary measures and regulations by which the Imperial Ottoman Government places obstacles in the way of foreign importers.—*Commercial Intelligence*, Dec. 8th, 1901, p. 15.

2. Industries.

Industrial Development.—*The War and the Industrial Development of South Africa.* The article deals in a general way with the natives of South Africa, the extent of trade, the coalfields and collieries of Natal, the West Rand coal mines, other minerals, the Cape Colony railways, the railway tariff, etc., and a forecast of the future.—*Iron and Coal Trades' Review*, Dec. 14th, pp. 1217-20. (Ill.)

Foreign Industries. — *German Conditions. The Industrial Situation discussed by Consul-General Mason.* Digest of the annual report of the above-named United States Consul at Berlin for 1900, which is to appear in the forthcoming edition of "Commercial Relations." The report submits abundant statistics showing the fluctuations in the receipts of twenty leading staples which form the bulk of German imports from the United States, the comparison being given in units of metric tons.—*Manufacturer*, Dec. 15th, pp. 35-37.

3. Labour.

Early Closing.—*The German Nine O'clock Closing Act.* Comments on the working of this ill-timed interference with trade interests, pointing out that while the Act affords next to no relief to the class for whose benefit it was devised—*i.e.* the employés — it greatly irritates important sections of the general public.—*Commercial Intelligence*, Dec. 8th, 1900, p. 14.

Strikes.—*Strikes and Lockouts in* 1899. Comments on the annual report of the Chief Labour Correspondent on the above subject recently presented to the Comptroller-General of the Commercial, Labour and Statistical Department of the Board of Trade, by Mr. H. Llewellyn Smith, covering the minutest details, classified and brought together in an easily accessible form.—*The Contract Journal*, Dec. 12th, 1900, p. 1122.

4. Miscellaneous.

Technical Education.—*Manual Training.* The writer points out the importance of developing manual dexterity during the period of education in our children, eulogises the government of the State of Massachussets for voting 25,000 dols. a year to towns who are willing to put up another 25,000 dols. for founding a textile school, and strongly supports the idea of asking Congress to vote money to enable the President to appoint a commission whose duty it shall be to study in the various countries of Europe the systems in use for manual training.—*Manufacturer*, Dec. 15th, 1900, pp. 20, 21.

Commencing with the May number, a series of articles dealing exhaustively with the Glasgow International Exhibition will be published in FEILDEN'S MAGAZINE.

These will be contributed by such well-known experts as Mr. James Wade (Textile Machinery), Mr. John Ashford, M.I.Mech.E. (Machine Tools), etc., etc., the writers dealing with the sectionised exhibits in a critical rather than a descriptive manner. The article in the May issue will form an introduction to the series.

REVIEWS.

A Text-Book on Gas, Oil, and Air Engines. By Bryan Donkin. Third Edition, revised and largely re-written. London: Charles Griffen & Company, Ltd., 1900.

The previous editions of Mr. Donkin's work are already well known in the engineering world, and the demand for the present issue is sufficiently indicative of the increasing interest that is taken in internal combustion motors of different kinds, and of the estimation in which the book itself is held. During the last few years so remarkable an increase has become evident in the number and power of gas and oil engines used for industrial purposes that the author has found it absolutely necessary to re-write a considerable portion of his book, which, therefore, still maintains its reputation as a thoroughly complete and modern exposition of the subject. Naturally, the book is a compilation so far as relates to the major part of its contents, but the professional reader may congratulate himself that it has been produced by a compiler thoroughly qualified to select the most suitable material, and to present it in the most acceptable form.

In the first chapter we find a general description of the action and parts of a gas engine, wherein it is remarked that the gas motor shows the advantage over a steam engine in that it possesses greater compactness and facility in starting. Theoretically, also, it is superior, because higher temperatures are available for acting upon the piston, but this advantage is not experienced in practice, because too large a proportion of the heat is wasted, and the best constructors have not yet succeeded in reducing the cost of working to that exhibited by the steam engine. We may, however, remark in passing that cases frequently occur where the gas engine actually saves money, even though the cost per h.p. may be more than in a steam motor. For instance, if a small power should be required, the cost of a stoker may very easily counter-balance all the advantage theoretically derivable from the adoption of a steam engine, and this effect will be emphasised in any case where power is required intermittently. The waste of heat in a steam engine, as our readers know, is very great, and there is further loss owing to condensation in the pipes communicating with the generator. In a gas engine there is no such waste, because all the heat is generated in the cylinder itself. Nevertheless, as Mr. Donkin says, "heat is lost, but in a different way." At the moment of explosion the temperature of the gas is probably about 2,730 degs. Fahr., and the heat is always too great for retention; a large portion must be sacrificed to prevent injury to the machine, and of the remainder a large proportion escapes in the exhaust gases. The more complete utilisation of heat evolved is the most important problem now confronting the gas engineer. Another essential consideration is the mechanical utilisation of motive force, and this includes a study of the construction and working parts of a gas engine, regarded as an apparatus for the transformation of heat into useful power. Before proceeding to examine in detail the typical examples, the author clears the way by enumerating the principal parts and internal organisation of a gas motor, as well as the different operations taking place in such a machine. Lubrication and speed regulation receive a few words of explanation in the preliminary chapter before the author passes on to the discussion of heat cycles and the classification of gas engines. Some writers have adopted the somewhat unsatisfactory method of classifying such motors by distinguishing them as horizontal or vertical.

Mr. Donkin divides gas engines into two main types. In Type 1, Class A includes non-compressing motors drawing in and igniting the charge at atmospheric pressure. The force of the explosion drives the piston forward and the return stroke expels the products of combustion. This class is best exemplified by the original Lenoir Engine. Class B represents vertical engines also drawing in and igniting the charge at atmospheric pressure. In this class the piston does no work on the upstroke, but on the return stroke it is locked to the crank and is forced down simply by atmospheric pressure. This type is best represented by the Otto and Langen Engine. In the Bisschof variety the piston is permanently connected to the motor shaft. Both these classes, as the author points out, are now practically obsolete. Within Type 2 are placed all engines using compression. In Class A the whole cycle of work occurs in the motor cylinder itself—in order to effect the various operations therein, one complete stroke must be sacrificed; and compression is obtained at the expense of power. The well-known Otto Engine is cited as typical of this class, which includes nearly all gas and all oil engines. In Class B the same cycle of operations obtains, but an auxiliary cylinder is employed, as in the Clerk Engine. There are very few engines which do not belong to either of these types, and such exceptions are fully described in later chapters.

Two extremely interesting chapters are those devoted to the History of the Gas Engine, first suggested in 1678 by the Abbé Hautefeuille in the form of a motor actuated by explosive powder. Very little appears to have been done towards the development of the idea for more than 100 years, because the efforts of scientific men and inventors were devoted to the application of steam to the production of power. None of the gas motors devised before 1860 were successful, and many of them, it is remarked, were never made. To Lenoir Mr. Donkin ascribes the credit of producing in 1860 the first practical working gas-engine.

It must, however, be conceded that much ingenuity was displayed by various early patentees, and the author points out that "scarcely a single improvement has been suggested in modern engines which may not be found in the drawings of Lebon, Barber, Street, Barnett, and others." Between 1860 and 1876 a number of ingenious motors were produced, which, although no longer made, were in many cases of good design and principle. Amongst these the best known are probably the Otto and Langen, the Bisschof, and the Brayton. With the introduction of the Otto

Gas Engine in 1876 a new era commenced. To Nicolaus Otto is given the credit of being able to put into operation the principles propounded several years earlier by De Rochas.

The Otto engine was not without its faults, which soon began to be recognised. One defect, which Mr. Dugald Clerk applied himself to remedy, was due to the fact that only one stroke out of every four was spent in positive work. This disadvantage was avoided in the Clerk engine —produced and exhibited in 1880—by the application of an auxiliary cylinder termed the "displacer." A full description of the motor is given, and forms interesting and instructive reading, although the Clerk engine is no longer made. Amongst other discarded gas-engines we notice particulars of the Beck (a six-cycle motor), the Tangye (somewhat resembling that of Clerk), and various less-known varieties. The close of this chapter disposes of purely historical references, although earlier practice is subsequently discussed to a certain extent. Before leaving this portion of the treatise we must express entire concurrence with the author in acknowledging the debt due to De Rochas for his accurate and invaluable formulation of the conditions essential to the efficiency of any gas engine. When first made public these conditions at once created a revolution in the study of this form of motor. His cycle of operations, known as the "four-cycle of De Rochas," differs from that of Carnot because it is not a theoretical, but a practical cycle. Many improvements have been effected in the mechanism of gas motors, but in essential points all are founded on the sequence of operations and the working conditions enunciated by the distinguished French engineer, De Rochas.

Chapter V. is devoted to the description of some engines that were devised either as improvements upon, or as alternatives to, the Otto type. Of these the Atkinson was a praiseworthy attempt to remedy the defective expansion which is the chief cause of heat loss in the Otto engine. Mr. Atkinson was the first to obtain ignition by the now familiar means of a red-hot tube; his patent is dated 1879, and the same method was adopted soon afterwards by Leo Funck. The original forms of the Griffin and the Stockport engines are fully discussed in this chapter, and the author then goes on to trace the history and development of the Otto engine from the year 1876 up to the present time.

Passing on to modern gas engines, Mr. Donkin points to two circumstances that have contributed within the last few years to the great development of gas as a source of motive power. The first is the extensive and increasing application of electricity to lighting, and the second is the expiration of the Otto patent. A great impetus was given to production when the monopoly ceased, and at the same time the sudden and universal competition reduced prices and increased sales proportionately. Messrs. Tangye were among the foremost to adopt the Otto cycle, and, next to Messrs. Crossley, they build some of the largest motors in England. This firm was also the first to introduce a gas hammer for forging purposes, somewhat on the principle of the steam hammer.

The author goes on to consider a large number of British gas engines, and when we state that nearly thirty varieties receive detailed attention, it may be possible for our readers to realise the thoroughly conscientious manner in which the subject has been treated. In the next chapter French engines receive ample consideration, the "Simplex" being fully described and illustrated. These machines are of undoubted economy, and are being made up to 1,500 h.p., the licensees being the Creusot firm in France, Messrs. Beer for small and the Société Cockerill for large powers, in Belgium, and a Roman firm in Italy. About fifteen French engines are mentioned altogether, but motors of Belgian origin are merely accorded eight lines, which appears rather inadequate treatment.

German engines, together with some of Austrian and Swiss manufacture, are described in a chapter covering about 26 pages, a perusal of which will repay the reader; but here again, in view of the exceptional activity of our competitors in these countries, we are of opinion that still further details might have been acceptable. Two most important questions are those of gas production for motive power, and the utilisation of high furnace gases, the former interesting to general users, and the latter more particularly to metallurgists. The utilisation of furnace gases has reached a more advanced stage on the Continent than in this country, but the subject is now receiving attention by our leading engineers and metallurgical experts. We strongly commend the chapter where these matters are discussed to the careful consideration of our professional readers.

The remaining portion of Part I. is occupied by a masterly exposition, relative to the theory of the gas engine, the chemical composition of gas, the utilisation of heat, and to explosion and combustion in the gas engine.

Part II., dealing with Petroleum Engines, commences with an account of the discovery, utilisation, and properties of oil, and the production of oil-gas. After a consideration of these matters, it is stated that petroleum can be utilised in four different ways for the generation of mechanical energy in a motor: as liquid fuel for the production of steam; as gas produced by destructive distillation; as gas naturally evolved from the lighter constituents of petroleum; and as gas produced by a vaporiser contiguous to the engine to be driven. All these methods present difficulties, owing to the complex nature of the oil, except when it is evaporated as a pure spirit. The difficulties and advantages attending the use of petroleum are ably discussed by the author, who then proceeds to describe some early oil engines.

The chief parts of an oil motor must be understood, as well as the respects in which it differs from a gas motor. After a brief reference to these points, Mr. Donkin furnishes a complete and interesting description of the Priestman motor, which is now made in sizes varying from 1 to 45 h.p. In the succeeding chapter nearly thirty British oil engines receive notice, but only three illustrations of the least use to the technical reader are given. This we think is rather unfortunate.

Possibly our readers may have noticed that no mention has hitherto been made of American gas engines. The reason for this apparent omission is that Mr. Donkin includes such machines under the heading of "American Gas and Oil Engines," in the section of his book supposed to treat exclusively of oil engines. The reason for this arrangement is that "the chief types made in the United States are mostly intended to be driven either with gas or benzine." Ordinary heavy petroleum engines are not much used in that country to generate power in an engine, lighter oils being preferred because they are cheap and abundant, as well as easier to handle. A large number of American, French, Swiss, and German oil engines are mentioned in the remaining pages of Part II., but only five sectional drawings are reproduced for the information of those interested in points of detail. When speaking of the Daimler motor, Mr. Donkin states that the cylinder water-jackets "are often dispensed with." In a stationary engine this would be practically impossible, and in all Daimler motors used on vehicles water-jackets are invariably fitted. Practical applications of gas and oil engines are summarised in a chapter which is instructive as showing the great impulse that has been given to industrial development by the introduction of these motors in various directions. After reference to their application to the purposes of electric lighting, waterworks, tramway traction, navigation, and agriculture, it is justly remarked that "the subject of mechanically driven carriages has now become far too large to be done justice to in this book, and requires a volume to itself." In connection with the paragraphs where motor carriages are mentioned, we may perhaps correct a slight inaccuracy which has crept into p. 431. It is there said that the Daimler motor carriage is made in France by MM. Panhard and Levassor, and by MM. Peugeot frères. We believe it is a fact that the latter firm do not make the Daimler car, but until the last few years have employed the old form of Daimler motor on a carriage of their own design, having a steel tube frame which is utilised for the circulation of water. The Daimler type of car has a framework of channel iron, and is therefore not adapted for water circulation in the manner described.

Part III. is devoted to the air engine, a form of motor which ought to be better in theory and more economical in practice than other types of heat motors, but is not. The volume concludes with a series of valuable tables recording the results of different tests, and there is also an appendix containing much useful matter. Speaking of the work generally, it may be said that there is nothing that could be spared. As a historical and descriptive text-book, it is written in so happy a style that it is equally acceptable to the professional engineer and to those engaged in kindred professions and trades, whilst it is eminently serviceable as a work of reference to anyone desiring reliable information as to heat motors. We think, however, that in one or two respects some further details might be added with advantage, especially in the interests of practical engineers. For instance, many of the illustrations are merely prints from wood-cuts, apparently designed for commercial prospectuses. If these were replaced by sectional diagrams, and if more illustrations of the latter class were included, they would be appreciated by engineers, who would be under further obligation if the author were to include some practical observations with regard to the care and management of gas and oil motors and to matters of construction and design. Additions of this nature would be all the more acceptable, because Mr. Donkin is most justly regarded as an authority upon whose knowledge and judgment absolute reliance may be unhesitatingly placed.

Hydraulic Power Engineering. G. Croydon Marks. Publishers: Crosby Lockwood & Son, London. Price, 9s. net.

The subject of hydraulics and hydraulic engineering is by no means over-written, and if for no other reason such a book as the one before us would be welcome. But Mr. Marks has done more than supply a bare want; he has given us an exceedingly interesting volume, well-written, and full of useful information; although, as he very ably points out in his preface, it would be impossible to adequately or comprehensively deal with such a wide field in a single volume. Nevertheless, after a careful study of this book, we consider that Mr. Marks has added a valuable contribution to engineering literature. We feel a little inclined to disagree with his statement that "the development of hydraulic power machinery has been somewhat of a modern movement," unless the word "modern" is used in a very general sense, because the use of hydraulic machinery dates back a very considerable way, and further, its development has been nothing like as rapid as several other branches of engineering. The principles of hydraulics are now well ascertained, and we look rather to the carrying out of these principles on an extended scale than for any striking departure from present-day practice.

The book is divided into eight parts, with the addition of a useful appendix, consisting of a table which shows the pressure of water in lbs. per sq. in. for every foot in height up to 270 ft. By means of this table, from the lbs. pressure per sq. in., the feed head is easily obtained, and *vice versâ*. There is also a table giving the action of pumps, with diameter, areas, and displacements. The parts deal with the following points: Part 1—Hydraulics, having reference to first principles. Part 2—Preliminary, treating with pressures, material, and test loads. Part 3—Joints and packings. Part 4—Valves. Part 5—Lifting machinery, including platform lifts, cranes of various kinds, and accumulators. Part 6—Hydraulic presses, comprising Baling and other presses, sheet metal working and forging machinery, riveters, etc. Part 7—Pumps. Part 8—Hydraulic motors, including turbines, water-wheels, hydraulic engines, etc. This last part also describes and illustrates some recent achievements in hydraulic engineering on a large scale, to which we must make some further

reference. We have referred to the various headings rather fully, since it gives intending purchasers of the volume some idea of what they will find in it, and we must say at once that we think that anyone who is associated in any way with hydraulic engineering would do well to study it for themselves. Omitting any further reference to Parts 1 and 2, which deal chiefly with first principles, and although of great importance to the student, are assumed to be generally known by the practical engineer (although not always, we fear), we may briefly refer to Part 3. This contains some useful hints in respect to joints and packings, and also some simple formulæ in order to ascertain the friction due to the use of the latter. There is also a table which gives the co-efficient of ram efficiency for hemp and leather packing. When high pressures are used, as in hydraulic engineering, the question of joints and packing is of great moment. This is also the case in respect to valves, and these are fully dealt with in Part 4. Various makers adopt different types of valves, and improvements are constantly being made in this direction. Mr. Marks illustrates by sectional drawings some of the principal types at present in use. Part 5.—We now come to lifting machinery, which, together with presses and metal-working machines, probably forms the most important application of the hydraulic principle. This will be found a very useful section, since it deals with the subject very fully, and includes some useful and simple formulæ. In the same section, reference is also made to various types of hydraulic cranes. It is true that compressed air has recently entered the field as a competitor both for foundry and warehouse purposes, but the hydraulic crane is not likely to suffer greatly.

Part 6.—This deals with Baling and other presses, and also sheet metal and forging machines. Of presses, an almost infinite variety are now made, and the references and tables given in this part will be found exceedingly useful both to manufacturers and users. Hydraulic machine tools are fully dealt with, and the latest types of the Tweddell system (Fielding & Platt), are described and illustrated. Part 6 is an exceedingly valuable section, and would alone make the book worth having.

Parts 7 and 8 deal extensively with pumps, water-wheels, hydraulic engines, and turbines, and, in connection with the latter, some carefully worked-out formulæ and diagrams, also designs of turbines in detail, are given. Part 8 also refers to recent achievements on a large scale in hydraulic engineering. This will be found both interesting and instructive, and includes a full description with excellent plates of the hydraulic docks at San Francisco. The lifts employed at these docks are capable of lifting a vessel of 4,000 tons weight to a height of 32 ft., and are probably the most powerful combination of hydraulic lifts in existence. Detail and general views are also given of the Tower Bridge; of various water-balanced railways and lifts, as at Lynton and Lynmouth, North Devon; of the 4,000 tons hydraulic forging press in use at the works of Charles Cammell & Co., Ltd., Sheffield. This is not the largest of its kind, since there are others working up to 10,000 tons power, but is a good example of the heavy forging presses which have largely superseded the steam hammer for this class of work. The Niagara Power Works are also illustrated and referred to. We may say in conclusion that the book is eminently practical, and suited to every-day requirements, and the absence of intricate formulæ is distinctly in its favour. We unhesitatingly recommend it to the notice of all engaged in engineering practice.

The Kinetic Theory of Gases. By Dr. Oskar Emil Meyer. Translated from the Second Revised German Edition by R. E. Baynes, M.A. xvi. and 472 pages, 1899. Longmans, Green & Co. Price 15s. net.

The first German edition of this book, which appeared in 1877, has had a large sale in England and America, and it is usually quoted as the standard work on the subject by the authors of text-books and other writings in which the kinetic theory of gases is treated or referred to. The second edition is very much enlarged and improved, though it is to be regretted that, as stated in the author's preface, want of time has prevented his discussing various recent investigations, which are more or less closely related to the subject of the work.

Put briefly, the kinetic theory of gases is the explanation of gaseous phenomena as produced by the to-and-fro motions, in straight lines, of its constituent molecules, their collisions and subsequent separations, and their impacts against the walls of the containing vessel.

Suggestions of such an explanation occurred to philosophers at a very early date; as for example, in the speculations of Lucretius; but as a scientific theory, it may be considered as taking its rise with Daniel Bernouilli's explanation, in 1738, of Boyle's law, connecting the volume and pressure of a gas at constant temperature; the next important contributions being the enunciation by Waterston in 1845, for the case of point molecules of varying mass, of what is now known as the Maxwell-Boltzmann law of equal partition of the kinetic energy among the different degrees of freedom, leading to their law of steady distributions; and the determination of the pressure of a gas by Joule in 1851, by breaking up the whole motion into three components, having equal momenta, at right-angles to each other, and thence deducing a method of determining the mean speed of the molecules of any gas under given conditions. The general theory was developed in a mathematical form mainly by Clausius and Maxwell, with some important contributions from Lord Kelvin, Boltzmann, Osborne Reynolds, and others.

The difficulties of the mathematical treatment debarred a large proportion of physicists from following the development of an extremely interesting line of investigation, until Dr. Meyer, in the first edition of the present work, developed it in a non-mathematical form, which could be followed by any reader of average intelligence,

In the translation of the second edition this experimental and other non-mathematical portions occupy 352 out of 466 pages, the remainder being devoted to mathematical appendices, which will enable readers, who possess the requisite knowledge, to follow the reasoning by which the more important results were arrived at prior to their being put to the test of experiment.

The non-mathematical portion is divided into three parts, dealing respectively with: molecular motion and its energy; molecular free paths and the phenomena conditioned by them; and, the direct properties of molecules.

The general development of the theory, with the experimental evidence, is very clearly set forth, and forms extremely fascinating reading, from the manner in which knowledge is unfolded, which would appear at first sight as though it must for ever remain hidden from us. The path was not so easy for the first explorers, who had to hew their way up the rugged mountain side by the aid of the powerful tools provided by some of our greatest mathematicians; but while the mathematical reader will be enabled, by means of the appendices, to follow these first explorers up their steep and difficult path, a much larger number will be glad to avail themselves of the easy staircase which the work of the pioneers has enabled the author to construct for the benefit of those who would be deterred by the mathematical difficulties from following the original paths.

The kinetic theory of gases does not, moreover, claim our attention only in virtue of its inherent interest, but because it is one of the means of investigating the phenomena of the relations between matter and ether, which are attracting so much attention at the present time, and concerning which we may expect considerable advances in knowledge and, very possibly, some startling practical developments before the new century is many years older.

Of the five chapters in the first division of the work, the first deals with general considerations and brief references to the work of the founders of the kinetic theory. The second chapter deals with questions of gaseous pressure, including the discussion of Boyle's and Dalton's laws, and the meaning of the so-called absolute zero of temperature.

The third chapter deals with Maxwell's law of equal partition of kinetic energy among the different variables, and the resulting conclusion as to the steady distributions of molecular speeds.

This subject is a most interesting but an extremely difficult one, and one upon which hardly any two physicists are entirely in agreement. For example, Lord Kelvin does not consider that the conclusion follows from Maxwell's assumptions, while Lord Rayleigh's opinion is the direct opposite.

The author gives several demonstrations of this law in the mathematical appendices, though not in our opinion, in the most convincing form in which they have been put, and in the portion addressed to non-mathematical readers he takes the only possible course of stating the law and comparing the deductions to be drawn from it with experience. On the whole, this is very well done, but we do not think he has set forth sufficiently clearly the magnitude of the difficulties involved in the acceptance of Maxwell's conclusions.

As Lord Rayleigh points out in the paper referred to above: In the case of argon, helium, and mercury vapour the ratio of the two specific heats (1·67) limits the degrees of freedom of each molecule to the three required for translatory motion, leaving nothing for rotation, and nearly as great difficulties occur in the case of diatomic molecules.

We do not ourselves see any possibility of refusing assent to Maxwell's conclusion if the applicability of Hamilton's principle, or of one of the equivalent integral principles of mechanics, to a system of gaseous molecules is admitted, as it is in the usually accepted system of mechanics. This seems to us to afford a typical case of the difficulties which Hertz's development of the principles of mechanics, recently reviewed in these columns, was designed to meet. From this point of view it would be open to us to overcome the difficulty by the conclusion that a system of gaseous molecules is not one to which such integral principles are applicable. This would mean that such a system is not subject to integral laws, or, in other words, that the differential equations which determine its motion are not all integrable, and an investigation from this point of view might not impossibly lead to interesting results.

Of the two remaining chapters in the first division, Chapter IV. deals with the comparison of actual gases with an ideal or so-called perfect gas; while Chapter V. treats of molecular and atomic energy.

Chapter VI., which opens the second division of the work, deals in a clear and interesting manner with molecular free paths, and this is followed by chapters on viscosity, diffusion, and conduction of heat, in the course of which a large number of most interesting phenomena are discussed and explained, in accordance with the kinetic theory, in a most lucid and convincing manner.

The last division of the work consists of a single chapter only of great interest, dealing with such subjects as determinations of the sizes of gaseous molecules, molecular forms, the chemical structure of molecules and allied matter. It concludes with some brief references to some of the theories of the constitution of atoms, such, for example, as Lord Kelvin's vortex atoms, and the pulsating atoms considered by Bjerknes and others.

It is much to be regretted that the author has been prevented, from want of leisure, from enlarging this last division of his able and interesting work, which is simply indispensable to anyone who wishes to become acquainted with this fascinating branch of scientific inquiry.

The translator's work is well done, and of the printing and general get-up of the volume it is sufficient to say that it is worthy of the reputation of the firm by which it is issued.

Mechanism of Weaving. By T. W. Fox. London: Macmillan & Co., Ltd., 1900.

This is a carefully and thoroughly revised edition of a treatise on power-looms and their working, which, ever since its first appearance, has been regarded as the standard authority on the subject, and will, with even greater justice, continue to be accepted as such, since it includes every modification of this kind of machinery up to the time of publication. The author has so arranged his material as to treat one after another the various steps and transformations of each separate motion, so as to follow it from beginning to end. It is doubtful whether the reader would get a better grasp of these successive steps had the author at the outset given a kind of sketch of the interaction of the various motions, which, when being treated as distinct, do not fully reveal their *raison d'être*. The looms described are divided into tappet, dobbie, and Jacquard or harness looms. In describing explicitly the tappet shedding motion the author refers to the Yorkshire tappet loom, Woodcroft tappets, and segment tappets. Passing over to the subject of dobbies, the author gives a full account, accompanied by sectional drawings, of the rather complicated mechanism of the principal types, and cotton weavers and manufacturers of light material will find numberless facts of interest and data of great importance for their trades. Woollen, linen, and worsted textures are treated only in passing, but there is contained in this volume a considerable amount of information of equal value for both cotton weavers and weavers of heavy materials. The gradual development of each subject is easily followed by the reader.

Starting with the single-lift machine, the various transformations of the Jacquard loom are described, such as the double-lift, centre-shed, open-shed, twilling, and finally the Bessbrooke and cross-border machines. The essential features of the different systems of tie-up are dealt with somewhat concisely, still the facts given will enable the reader to understand the principles underlying the complicated mountings. An exception to the condensed style necessary in order to include all the important types are the pages devoted to the doup and gauze harness, which are dealt with very fully and clearly. As regards lappet weaving, some methods, such as the Scotch, are lucidly illustrated, but methods in which the weaving is not effected by means of lapped wheels are merely mentioned. The pages devoted to picking contain many interesting facts, and the defects still existing are made very clear. Fast and loose reeds and shuttle guards are dealt with under the heading of "Warp Protectors," and there is a special chapter on "Multiple Box Motions" which is remarkable for lucidly explaining a by no means simple subject. The above are a few of the prominent features of this very praiseworthy treatise, but to fully appreciate its value is only possible after reading every page of it; and those who are connected with the weaving industry will certainly have to hunt far and wide before finding anything even approaching to it in the extensive literature on the subject. Even the general reader who delights in studying ingenious mechanical devices, though he may know but little of weaving, will find many fascinating facts in the pages of this volume, which we can thoroughly recommend to all interested in the subject.

Report of the Tramways Sub-committee on the Systems of Traction in various Towns, and on Electric Tramways for Leicester. November, 1900.

This volume, which is well got up and illustrated by numerous most excellent photographs, is the result of the journeyings through various British and Continental towns of the borough engineer of Leicester, accompanied by his colleagues of the Tramways Sub-committee of the Corporation of Leicester, in search of a system of electric traction suitable to the requirements of the borough. This at least is what the volume purports to be. Probably, if we were admitted behind the scenes, we might find that the real object of the town was to educate the members of the sub-committee to the extent of so far realising that the problems of electric traction were not for the comprehension of the ordinary town councillor, as to lead them to form a quiet and docile team ready to the hands of the coachman, in the shape of the electric traction expert who was ultimately to formulate the scheme.

The process of breaking in the town councillor to run quietly in harness necessarily made some demands on the borough ratepayers, but those will least be disposed to cavil at this expenditure who know most of the troubles which are continually arising from an electric lighting or traction committee starting work while still in a condition which would not be ill represented by a team of fractious colts put into harness for the first time.

The conclusion at which the sub-committee have arrived, that the overhead trolley system is the most suitable one for them to adopt, is what any electric traction expert would have told them beforehand was the correct one; but the fact of their having arrived at it apparently with perfect unanimity affords a reasonable presumption that the driver knew his business so well that even when new hands have to assume the reins the team may be trusted to obey their guidance without danger of upsetting the coach.

BOOKS RECEIVED.

Morison's Chronicle of the Year's News, by George Eyre-Todd, Morison Bros., 52, Renfield Street, Glasgow, 3/6 net.; Practical Electro-Chemistry, by Bertram Blount, Arch. Constable & Co., Ltd., Westminster, The Macmillan Co., New York, 15/- net; Practical Electrical Testing in Physics and Electrical Engineering, by D. Aspinall Parr, Longmans, Green & Co., 39, Paternoster Row, 8/6; Experimental Engineering, by W. C. Popplewell, The Scientific Publishing Co., Manchester, 10/6.